PLANERS AND
PLANER PRACTICE

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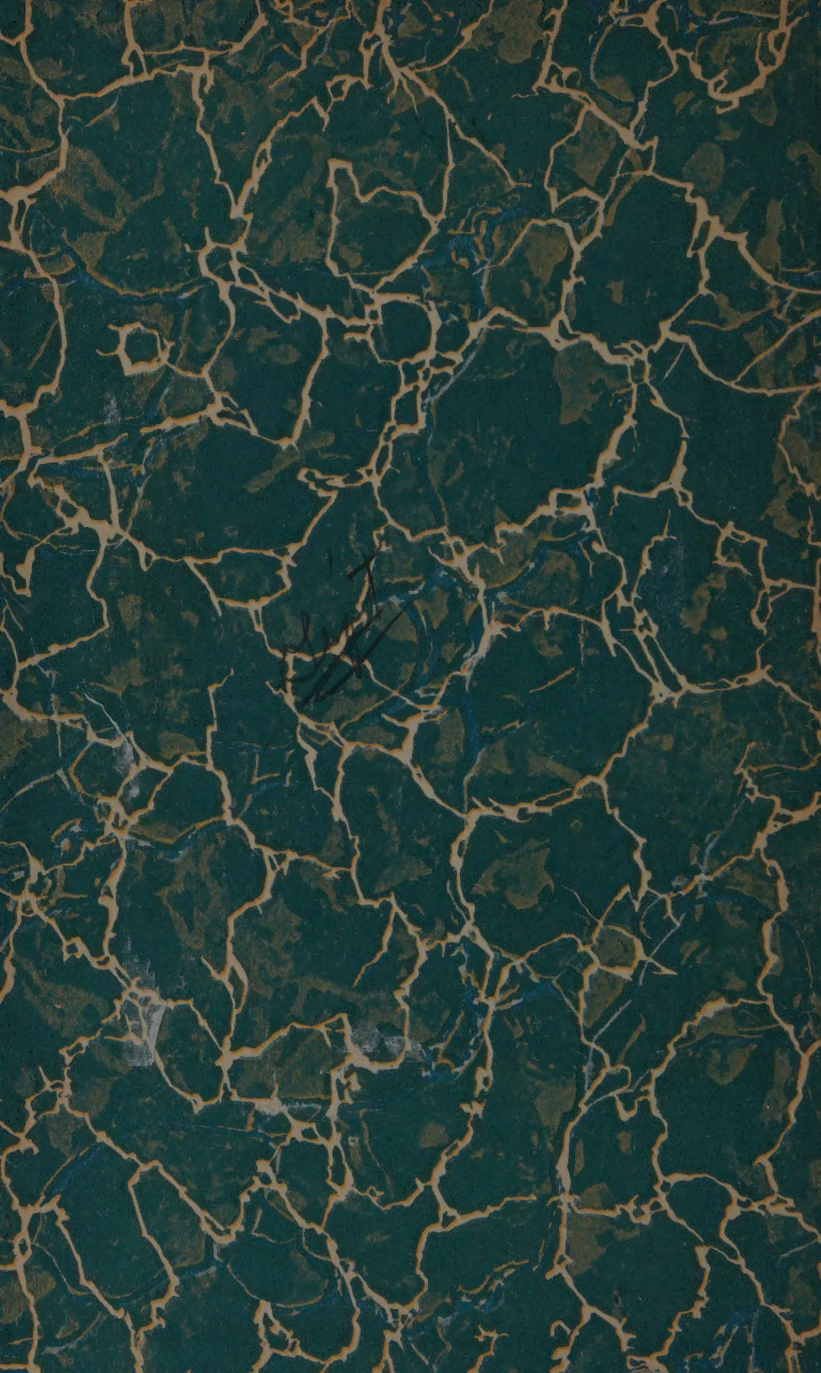

Planers and Planer Practice

By
I.C.S. STAFF

PLANERS
PLANER PRACTICE

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PLANERS

Serial 2212-2 Edition 1

DETAILS AND EQUIPMENT OF PLANERS

PLANER DETAILS

GENERAL DESCRIPTION OF PLANER

1. Purpose of Planer.—The planer is a machine tool intended primarily for machining flat surfaces, although it may be used to produce curved surfaces as well. The work to be planed is firmly fixed on a table that moves to and fro under the cutting tool, and the tool is fed across the work in a direction at right angles to that in which the table moves. The advantages of the planer over other machines for making flat surfaces are that it is stiffer and will handle larger work, or a greater number of similar pieces at one time. The planed surface is more easily scraped to a bearing or polished because the tool marks are parallel and continuous.

2. General Arrangement of Planer.—The general arrangement of the parts of a planer is shown in Fig. 1. The table *a*, often called the platen, has several lengthwise rows of holes and T-shaped slots to receive the devices that are used to hold the work. On the under side of the table, near the sides, and extending nearly its full length, are two V's that fit corresponding grooves, or ways, *b* formed in the top of the heavy bed *c*. Along the middle of the under side of the table is a rack that meshes with a large driving gear, or bull wheel, which rotates first in one direction and then in the other, thus moving the

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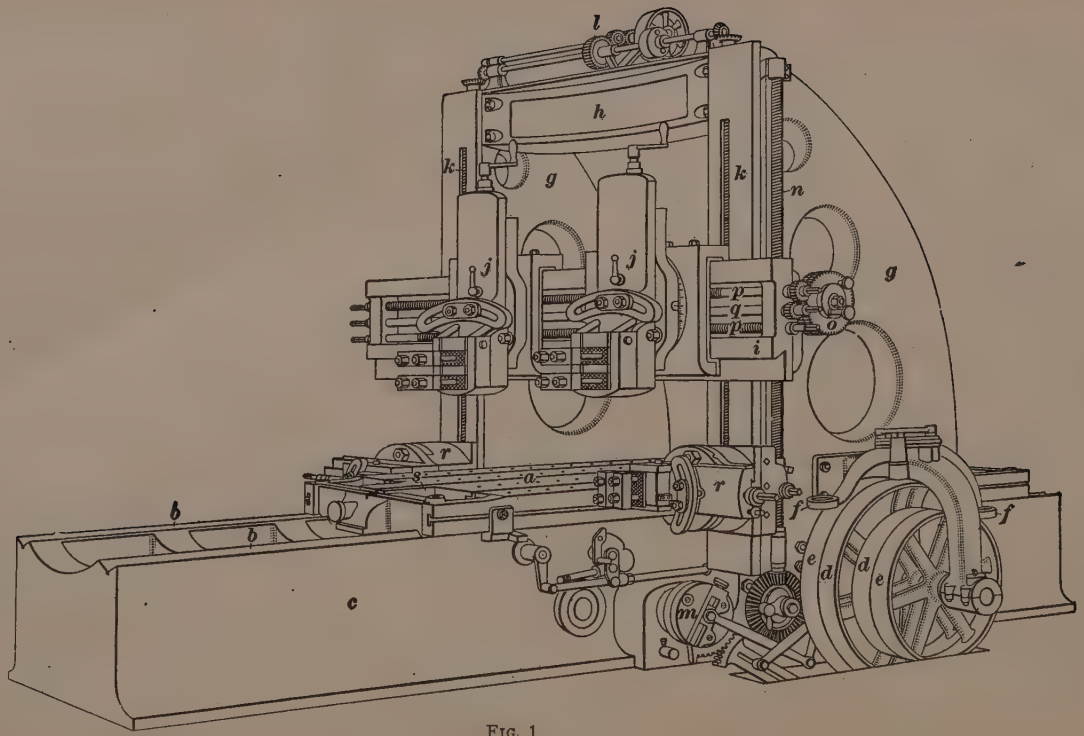

FIG. 1

table to and fro in the ways. The bull wheel is driven through a train of gears from the pulleys *d*, which in turn are belted to a countershaft, one belt being crossed and the other open, so that the large and small pulleys *d* rotate in opposite directions. The pulleys *e* are loose on their shaft and the belts from the countershaft pass through the loops in the ends of the arms *f*. These arms are moved when the table reaches the end of its stroke, thus shifting the belt from one pulley *d* to its corresponding loose pulley, and shifting the other belt to the other pulley *d*, thus reversing the motion of the table.

3. On opposite sides of the bed *c*, Fig. 1, are bolted the heavy uprights, or housings, *g*, which are braced at the top by the arch *h*. The front faces of the housings are finished and against them is fitted the cross-rail *i* that carries the planer heads *j*. The cross-rail is raised and lowered by turning the two elevating screws *k*, the motion being given by the gearing *l* on the top of the arch. On the smaller sizes of planers, the cross-rail may be raised or lowered by hand. The planer heads *j* carry the cutting tools, which may be fed downwards or crosswise as the work is moved to and fro beneath them by the table. The feed-friction *m* gives motion, through a rod and a gear segment, to a vertical rack just behind the screw *n*, and the rack drives a pinion on the same shaft as the trigger gear *o*. Motion is thus given to the feed-screws *p* by which the heads *j* are moved sidewise along the cross-rail, and to the feed-rod *q* that may be used to move the tool vertically. The ends of the rods *p* and *q* are squared to receive cranks by which they may be turned by hand.

4. In the planer shown in Fig. 1, a side head *r* is placed on each housing. These side heads are similar to the heads on the cross-rail, and may be moved up or down along the faces of the housings; also, the tools carried by them may be fed horizontally across the work on the table. On small planers only one head is used, but on those for work 30 inches or more in width it is usual to fit two heads to the cross-rail. Large planers generally have two side heads in addition to the two heads on the cross-rail. The side heads are used when planing the sides of

a piece of work at the same time that the heads on the cross-rail are used for planing the top surface; also, they are used for making undercuts.

5. Stating Size of Planer.—The size of a planer is given by stating the width, height, and length of the largest piece that can be planed on its table. Thus, a 48″×36″×10′ planer is one that will allow a piece of work 48 inches wide and 36 inches high to pass between the housings beneath the cross-rail, and that will plane a piece 10 feet long on its table. The

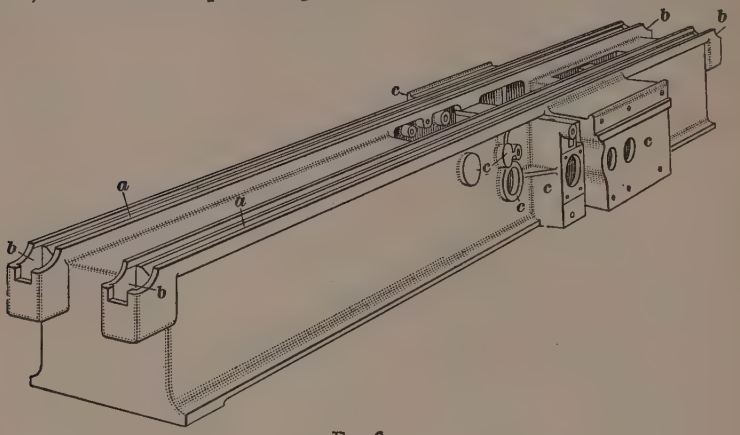

FIG. 2

numbers are always stated in the order mentioned; that is, the width is always given first, the height next, and the length last. The width and the height are usually the same.

PARTS OF PLANER

6. Planer Bed.—A form of planer bed is shown in Fig. 2. It is a deep box-shaped casting provided with cross-ribs and webs to insure stiffness and freedom from sagging or warping; for the bed supports the ways *a*, which must be perfectly straight and parallel to produce true work. The pockets *b* collect the lubricant that works out along the ends of the ways. This oil is led to a filter under the bed, after which it is used again for lubricating the ways. Except on the shorter types of planers,

the length of the bed is made about twice that of the table, so that, when the table is at the ends of its longest stroke, it will not overhang the ends of the bed. The pads *c* at the side are seats for the attachment of the housings and the driving gear.

7. Planer Table.—A cross-section of a planer table is shown in Fig. 3 (*a*), and a view of the under side of the table in (*b*). It is of box form, strengthened by cross-ribs and by a

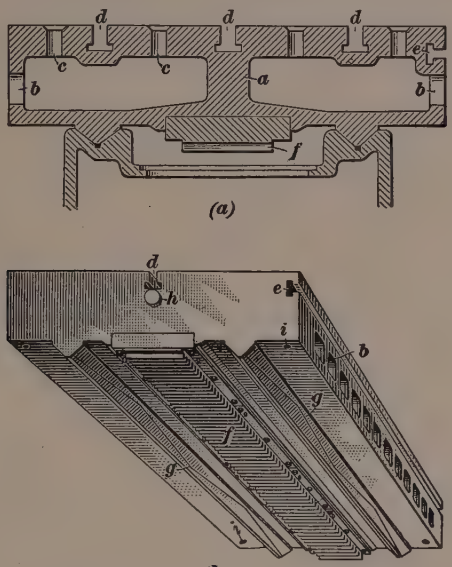

FIG. 3

heavy web *a* from end to end at the middle. The openings *b* in the sides are for the removal of chips that fall through the holes *c*, as well as for access to nuts or keys used in connection with bolts by which the work is held to the table. The T slots *d* extend nearly the full length of the table on the upper face and serve to accommodate chucks, strips, and T-head fastenings by which work may be secured. The slot *e* on one or both edges of the table holds the adjustable dogs by which the reversing mechanism is actuated. The rack *f*, with which the bull wheel meshes, consists of several similar sections bolted end to end along the middle of the table underneath.

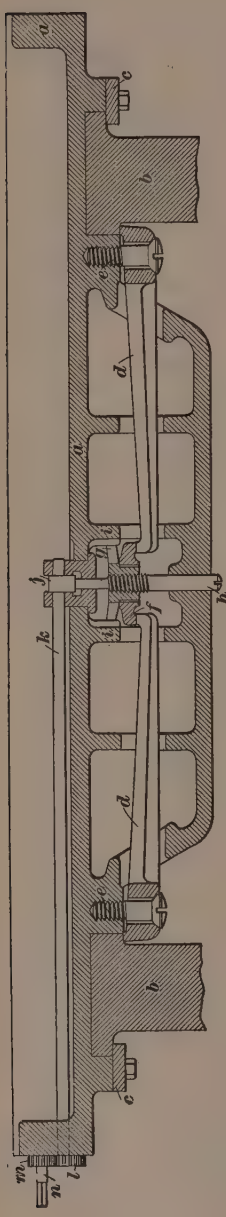

FIG. 4

8. The oil for lubricating the bearing surfaces of the V's and the ways, Fig. 3, is distributed by oil channels *g* cut in zigzag fashion along the V's. At each end of the table there is usually a lug *h* to which the sling of a crane may be attached when the table is to be lifted. In some cases, holes *i* through the table at the four corners enable eyebolts to be fitted for lifting the table. These holes also serve for the attachment of special devices for holding down the work. In order to be supported during the whole length of the stroke, the table should not be more than half the length of the bed; but in practice the table is not always used at full stroke, and it is sometimes made about three-fifths the length of the bed. Pockets at the ends of the table catch oil and chips. Such pockets are shown at *s*, Fig. 1.

9. Hand - Operated Cross - Rail Clamp.—The cross-rail must be firmly clamped to the housings before a cut is taken. On small planers, this is done by the use of clamp bolts at the ends of the rail; but on large planers, lever clamps are used, operated by either hand or power. A hand-operated clamp is shown in Fig. 4, which is a horizontal section of the rail and the housings. The cross-rail *a* is held in place against the housings *b* by the straps *c* at the ends. It is clamped in position by the action of two similar levers *d* that have broad flat ends which bear against a shoulder on the back of the

housings. The levers are fulcrumed on bolts *e* screwed into the cross-rail, and their long arms bear against a collar *f* that fits over a nut *g* screwed on the rod *h*. Wings on the nut slide in guides in the cross-ribs *i*. The end of the rod *h* rests against a cam *j* keyed to a shaft *k* on the outer end of which is a gear *l* meshing with a similar gear *m* on the stud *n*. A crank is fitted to the squared end of the stud and turned, thus rotating the shaft *k* and the cam, forcing the rod *h* inwards and swinging the arms *d* on their fulcrums, so that their short ends bind against the backs of the housing and hold the cross-rail firmly. The clamp is released by turning the crank on the stud *n* in the opposite direction.

10. Motor-Operated Cross-Rail Clamp.—A rear view of a large cross-rail with motor-operated clamps is shown in Fig. 5 (*a*) and a section is shown in (*b*). The rail is clamped and held by two wide arms *a* and *b* fulcrumed on the pairs of bolts *c* on the cross-rail. The outer ends of the clamps are adjacent to the faces of the guides *d* on the housings and their inner ends are fitted with rollers *e* that bear against wedge-shaped blocks *f* on the outer ends of the rods *g* and *h*. The inner end of the rod *g* has a left-hand thread and the rod *h* has a right-hand thread. These threaded ends fit into a sleeve *i* on which the gear *j* is mounted. The pinion *k* on the shaft of an electric motor *l* meshes with the gear. The wedge-shaped blocks *f* bear against rollers *m* on their straight sides. When the cross-rail is to be clamped to the housings, the motor *l* is started so as to rotate the sleeve *i* and draw the rods *g* and *h* together. The blocks *f* are thus drawn toward each other, and their inclined faces force the rollers *e* outwards, swinging the arms *a* and *b* on their fulcrums and causing their outer ends to grip the guides on the housings. Reversing the motor releases the clamps.

11. Planer Head.—Views of a planer head are shown in Fig. 6, together with a part of the cross-rail on which it is mounted. In (*a*) is shown a front view, in (*b*) an end view, and in (*c*) a view of the back of the saddle *a* when removed from the cross-rail *b*. The saddle is dovetailed along its back

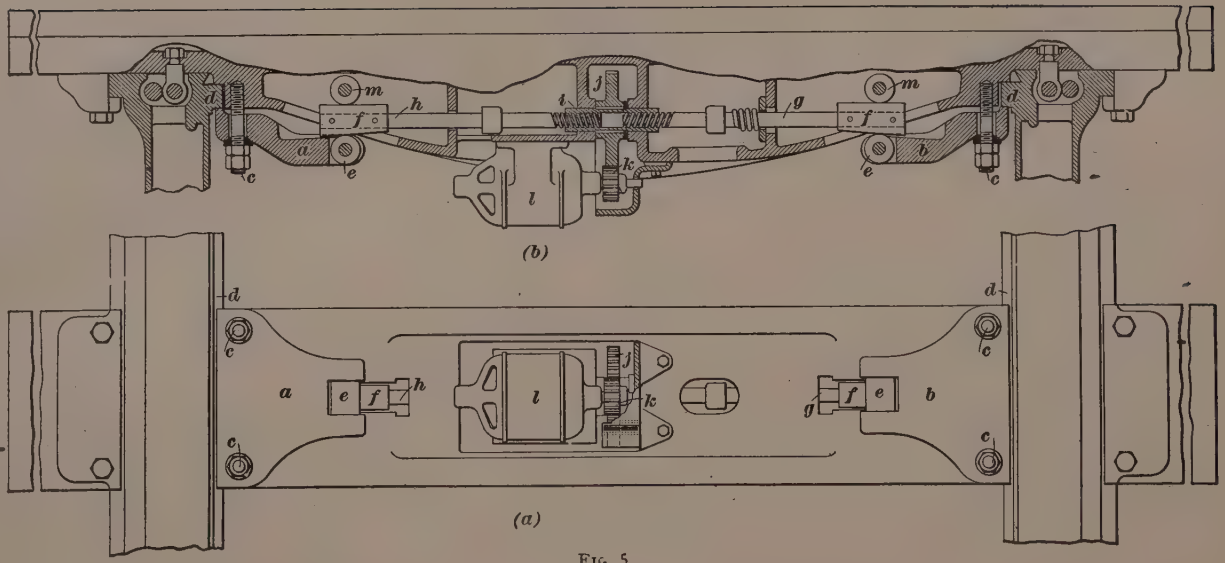

FIG 5

and is moved along the cross-rail by the screw *c*. This screw passes through a nut *d* fixed to the saddle, so that, when it is turned, the saddle is moved. A second head mounted on the cross-rail is driven by the lower screw. On the front of the saddle the swivel plate, or harp, *e* is mounted, and it is so attached that it may be swung to one side or the other, thus inclining the tool at an angle, for planing bevels. By means of the bolts *f* it may be clamped tightly to the saddle. Gibs *g* are inserted between the saddle and the upper edges of the cross-rail, and a binding screw *h* is provided to clamp the saddle to the cross-rail. The slide *i* is carried by the swivel plate and may be moved up or down by turning the handle *j* on the screw *k*; it is locked in position by the binding bolt *l*. At the lower end of the slide *i*, the apron box *m* is swiveled, so that it may be swung to either side, thus allowing the tool to swing away from the side surface of the work being planed, on the return stroke of the table. It is slotted at the top, to allow it to be swung, and it may be clamped in the desired position by the bolts *n*.

12. Tool Block.—The tool block *o*, Fig. 6, also called the apron, or the clapper, swings on a pin *p* that passes through the sides of the apron box. In small planers, the tool block usually carries a tool post with a screw to keep the tool in place; but in large planers it carries one or more clamps *q* in which the tool is held. The tool block bears solidly against the apron box during the cutting stroke, but swings outwards and upwards on the pin *p* during the return stroke. The tool is held firmly against a checkered plate that prevents it from slipping. The down-feed motion of the screw *k* is obtained from the feed-rod *r* through the bevel gearing *s* and *t*. The bevel gear at *t* forms a nut that fits over the screw *k* and is held in the swivel plate *e*, so that, when it is turned by the turning of the shaft *r*, the slide *i* is moved up or down. The down-feed motion is thrown into or out of action by moving the lever *u*.

13. Graduation of Planer Head.—In order to show how far from its central position the swivel plate is turned, graduations are marked either on the swivel plate or on the saddle at

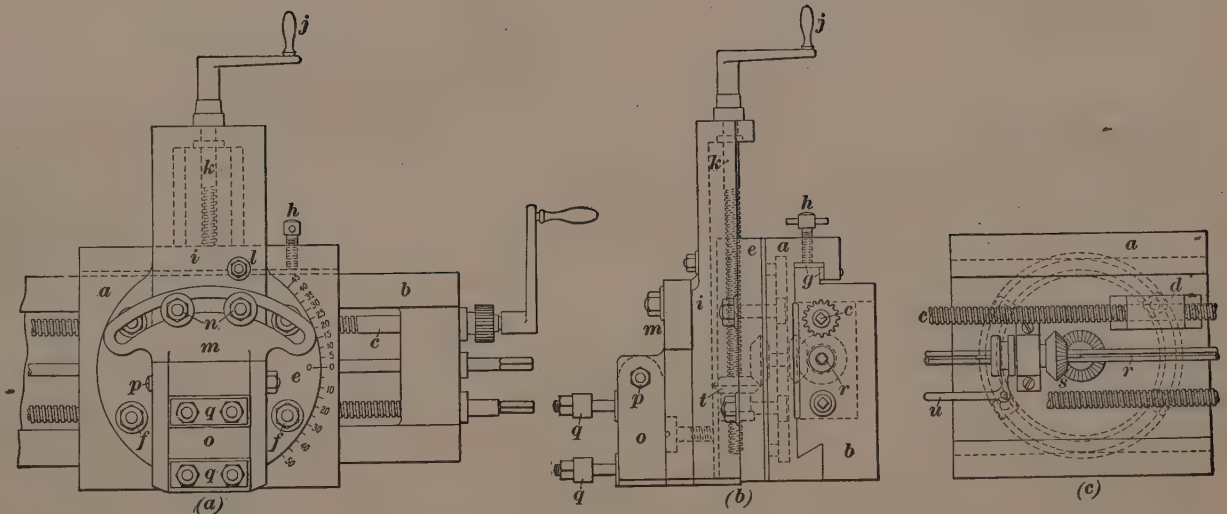

FIG. 6

the edge of the swivel plate, as shown in Fig. 6 (*a*). By means of these graduations, the head may be set at any desired angle to the work. Two ways of marking the graduations are shown in Fig. 7. In (*a*) the zero mark on the saddle *a* is opposite the 90° mark on the swivel plate *b* when the latter is in its central position, and the graduations run from 90° toward zero on each side of the 90° mark. In (*b*) the graduation corresponding to the zero on the saddle *a* is marked 0, and the graduations extend in each direction on the swivel plate. Side heads are graduated in the same ways.

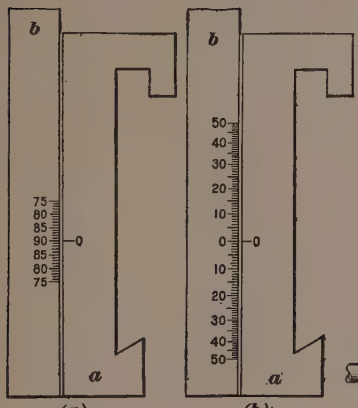

FIG. 7

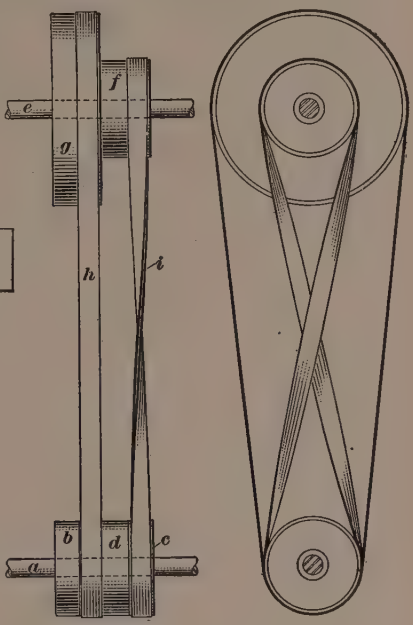

FIG. 8

PLANER MOTIONS

14. Quick-Return Motion.—The planer cuts during the stroke in one direction only, and in order to save time it is desirable to reverse the table and get it back quickly, ready for the next cutting stroke. The return stroke is usually made in one-half or one-third the time of the cutting stroke. The old form of quick-return motion is shown in Fig. 8. On the driving shaft *a* of the planer are two loose pulleys *b* and *c* and a

tight, or fast, pulley *d*, all of the same diameter. The countershaft *e* from which the planer is driven carries two pulleys *f* and *g*, the former being of the same diameter as the pulleys *b*, *c*, and *d*, and the latter twice as great in diameter. The large pulley *g* on the countershaft drives the tight pulley *d* on the planer during the return stroke of the table, and then the belts are

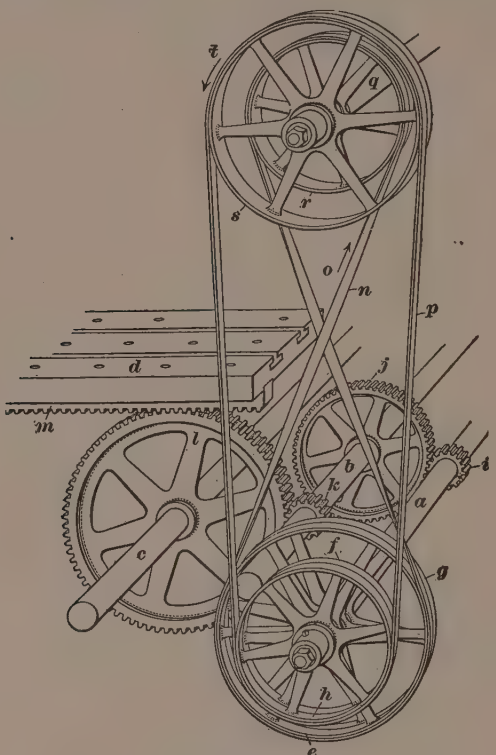

FIG. 9

shifted so that the open belt *h* runs on the loose pulley *b* and the crossed belt *i* runs on the fast pulley *d*, causing it to run in the opposite direction. The pulley *f* then drives the pulley *d* on the cutting stroke of the planer. As the pulley *g* is twice as large as the pulley *f*, it will drive the pulley *d* at twice the speed obtained when the pulley *f* is driving, and thus the speed of the return stroke will be twice that of the cutting stroke; or,

expressed in another way, the return stroke of the planer table will be made in half the time required for the cutting stroke.

15. Another quick-return motion of the older type is shown in Fig. 9. In this case there are two loose pulleys *g* and *h* and two tight pulleys *e* and *f* on the main shaft *a*. On the countershaft *q* are fixed the two pulleys *r* and *s*, both of which turn in the direction of the arrow *t*. The chief difference between this arrangement and that shown in Fig. 8 is that two tight pulleys *e* and *f*, Fig. 9, are required instead of a single wide pulley. The rapid return stroke is due to the fact that the pulley *f*, which drives the table on the return stroke, turns at a much greater speed than the pulley *e*, which drives on the cutting stroke.

16. Use of Aluminum Pulleys.—Considerable power is required to stop the planer table and the driving pulleys and set them in motion in the reverse direction. The slipping of belts during the reversal of motion wears them rapidly, and the screeching noise they make in slipping is disagreeable. Because the pulleys turn at a high speed and the table moves slowly, more power is required to stop the pulleys, reverse them, and bring them up to speed than is required for the same action on the table. One method of reducing the power needed for reversal, and at the same time reducing noise and wear of the belts, is to use aluminum pulleys. These are much lighter than the ordinary ones of cast iron or steel, and so they are more easily stopped and reversed.

17. Belt-Shifting Motion.—The planer-table motion is reversed by shifting one belt off a tight pulley on the main shaft of the planer and at the same time shifting the other belt on to a tight pulley. As the belts turn this main shaft in opposite directions, because one of them is open and the other is crossed, the motion is reversed every time they are shifted. A common method by which the shifting is done is shown in Fig. 10. In this case there is one broad tight pulley *e* and two narrow loose pulleys *f* and *g*. The belt to the pulley *f* passes through the

opening at the end of the arm *h* and the belt to the pulley *g* passes through the end of the arm *i*. These arms are pivoted at *j* and *k* on pins attached to the bracket *l*, and each may be swung over the pulley *e* in turn by moving the arm *m* first in one direction and then in the other. The belts are thus alternately shifted to the tight pulley. The arm *m* is pivoted at *n* to the bracket *l* and is connected by a rod *o* to an arm *p* pivoted at *q*. There is a slot in the side of the table, in which two adjustable

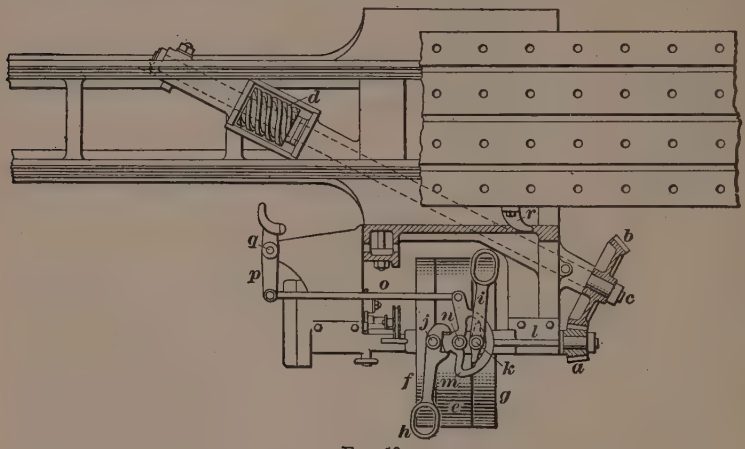

FIG. 10

dogs are bolted, one of which is shown at *r*. These dogs are so placed that when the table has completed its required stroke in one direction, one dog strikes the curved end of the arm *p*, turns it on the pivot *q*, moves the rod *o* and the arm *m* and thus shifts the belts so as to reverse the motion. When the end of the required stroke in the other direction is reached, the other dog strikes the arm *p* and the belts are shifted in the opposite direction, again reversing the motion. The positions of these dogs therefore determine the length and position of the stroke.

PLANER DRIVES

GEARED DRIVES

18. Spur-Gear Drive.—The drive of a spur-geared planer is shown in Fig. 9. The shafts *a*, *b*, and *c* are carried by the bed and are at right angles to the direction of motion of the table *d*. The shaft *a* projects outside the bed and carries the driving pulleys *e* and *f* and the loose pulleys *g* and *h*. The two latter pulleys are free to turn on the shaft *a*. A small gear-wheel, or pinion, *i* on the end of the shaft *a* gears with the large wheel *j* on the shaft *b*, and a second pinion *k* on the shaft *b* drives the bull wheel *l* that gives motion to the table by driving the rack *m*. Helical and herringbone gears are used in place of the spur gears on some planers. When the crossed belt *n* is running in the direction of the arrow *o* and driving the tight pulley *e*, the table *d* will be moved toward the right, or on its cutting stroke. At this time the open belt *p* is running on the loose pulley *h*. When the table reaches the end of its stroke, both belts are shifted, the belt *n* being moved to the loose pulley *g* and the belt *p* to the tight pulley *f*. As the pulley *f* turns in the opposite direction from the pulley *e*, the table is moved toward the left, or on its return stroke. To prevent wear and noise in shifting the belts, the motion is so timed that one belt is removed from its tight pulley before the other is moved on its tight pulley.

19. Screw-Gear Drive.—The screw drive is found on some old styles of planers. A screw of large diameter extends the full length of the planer, under the table and midway between the V's, and engages with a nut that is fixed to the under side of the table. The screw is driven by suitable gearing at one end, and when it rotates the table is moved.

20. Worm-Gear Drive.—The drive of a worm-geared planer is shown in Fig. 11. The table *a* has a rack *b* engaging with the bull wheel *c*, and the bull wheel is driven by the pinion *d* on the shaft *e*. On the outer end of this shaft is a worm-

wheel g that is driven by the worm f on the same shaft h with the tight and loose pulleys. The motion given by belt to the shaft h is transmitted through the worm and the worm-wheel to the bull wheel and the table. As the main shaft h is parallel to the line of motion of the table, this planer is also said to be *parallel-driven*.

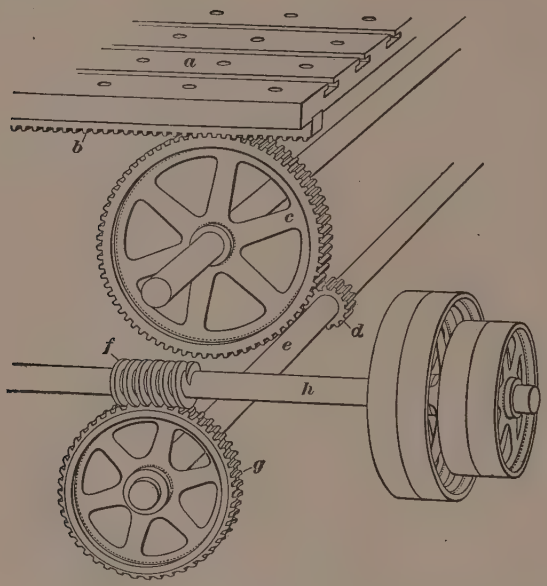

FIG. 11

21. Spiral-Gear Drive.—A top view of a spiral-geared planer with the housings and sections of the table and bed broken away is shown in Fig. 10. The shaft on which the belt pulleys are carried has at one end a bevel pinion a that gears with the bevel wheel b on the diagonal shaft c that extends through the bed beneath the table. The worm d is fixed on the shaft c directly under the center of the table and meshes with a rack on the under side of the table. The threads on the worm are cut spirally and slant at an angle to the shaft on which the worm is fixed. The shaft is therefore set diagonally in the bed, so that the worm threads at the points where they engage with the rack are at right angles to the line of motion of the table.

When the worm is turned, a direct pull or thrust is put on the rack, thus moving the table. A very steady motion is given to the table by this style of gearing, which for some purposes is much more satisfactory than spur gearing; also, it is much quieter in operation than spur gearing.

22. Second-Belt Planer Drive.—In order to attain high table speeds, as may be required when planing brass, aluminum,

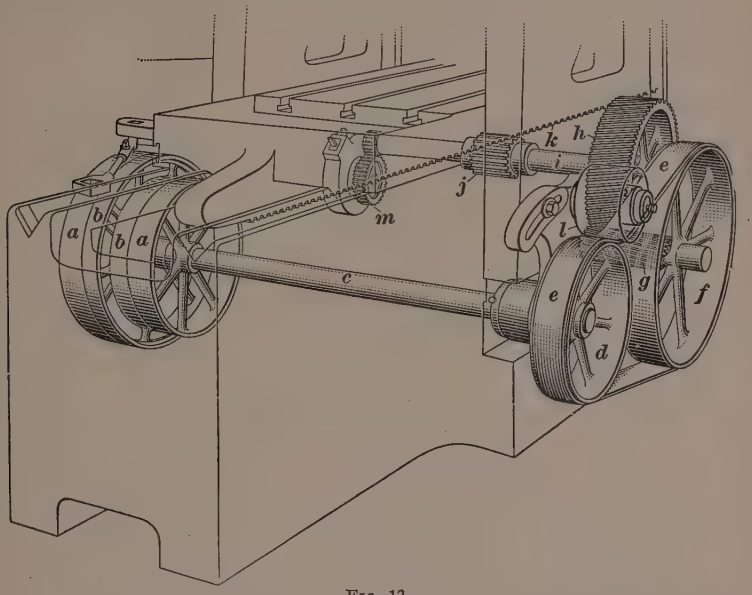

FIG. 12

and other non-ferrous metals, and to attain quiet operation at reversals, the second-belt drive shown in Fig. 12 has been devised. On this planer the bull wheel and gear drive within the bed on other planers have been replaced by a belt. The two separate loose pulleys *a* and the two combined driving pulleys *b* are operated the same as is explained in Fig. 9 to attain the two strokes of the planer table. The drive shaft *c* extends through the bed and carries a pulley *d* which drives the double endless second belt *e* and larger pulley *f*. There is a further reduction of speed by means of the helical pinion *g* on the hub of the pulley *f* and the large gear *h* on the shaft *i* that has the

pinion *j* to drive the rack *k* on the under side of the table. An idler pulley *l* mounted on an adjustable arm is used to keep the belt *e* tight. The mechanism for the friction feed is shown at *m* and is the same as is described in detail later on other planers.

23. Driving by Overhead Motor.—Where a line shaft is not used to drive a planer, the belts that run on the drive pulleys usually receive motion from an electric motor mounted on top of the arch, as shown in Fig. 13. In this particular case, the

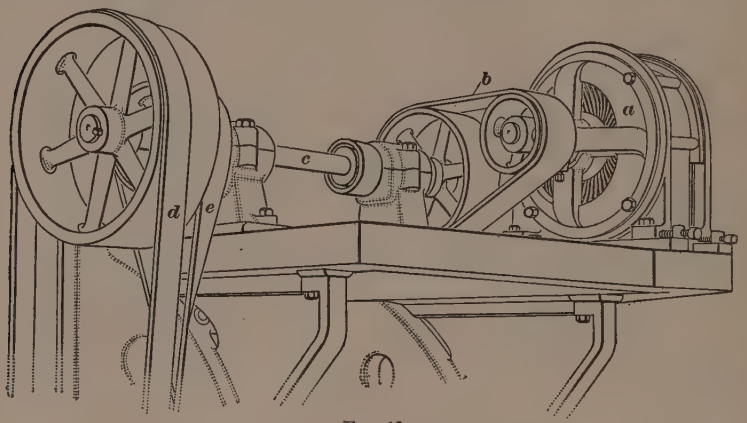

FIG. 13

motor *a* is connected by a belt *b* to the pulley on the shaft *c*; but, the connection between the motor shaft and the shaft *c* may be made by gears, or the motor may be connected direct to the shaft *c*. The belts *d* and *e* lead to the reverse and drive pulleys on the planer. By using a variable-speed motor, several different cutting and return speeds may be obtained.

24. Driving Planer by Reversible Motor.—If a reversible electric motor is used to drive a planer, no pulleys, belts, or clutches are required, and less power is used for reversing, so that a smaller motor may be used than in the belt-driven type; also, the operation of the planer is less noisy. The reversible motor is automatically controlled to act as a brake and slow down the planer table at the end of each stroke, as well as to increase the table speed rapidly after each reversal. A planer

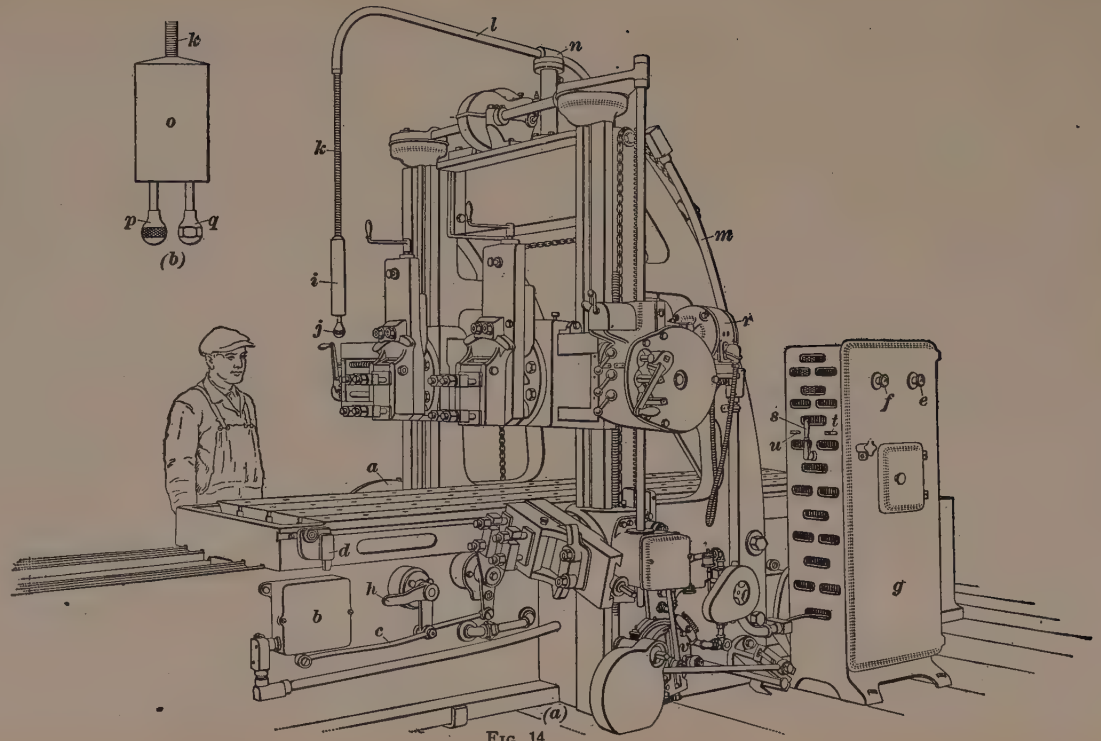

FIG. 14

fitted with a reversible motor is shown in Fig. 14 (*a*). The motor *a*, which is located at the back of the planer to be out of the way, is directly connected to the drive shaft by a flexible coupling, so that shocks to the driving gear are eliminated. Reversal of the motor is accomplished by a master switch *b* moved by the rod *c*, which in turn is actuated by dogs, as *d*, in the slot at the edge of the table. The motor speeds for the cutting and return strokes, which are independent of each other, are varied by turning the knobs *e* and *f* on the control box *g*. The motor, and consequently the movement of the table, may be reversed by hand by operating the lever *h* so as to throw the switch *b*. A similar lever is located on the opposite side, so that the operator can control the table from either side. Electrical equipments must be kept free of metallic chips, dust, and excessive oil.

25. Control by Single Pendant Switch.—One of the greatest advantages of driving a planer by a reversible motor is the ease of control, and the pendant switch makes this possible. Such a switch, of the single type, is shown at *i*, Fig. 14 (*a*). It is operated by moving the knob *j*, which is suspended by a flexible cord *k* that extends through protecting metal conduits *l* and *m* to the control box *g*. A swivel support at *n* enables the pendant switch to be swung to any convenient position within reach of the operator. The motor is stopped by pushing up the knob *j*. In this position, the knob may be turned in either direction, thus starting the motor very slowly in a corresponding direction. Then, pulling the knob down gives normal speed of operation in the desired direction.

26. Control by Double Pendant Switch.—In place of the single switch *i*, Fig. 14 (*a*), a double pendant switch may be used. Such a switch is shown detached in (*b*). The body *o* is connected to the flexible cord *k* in the same way as the single type. There are two knobs *p* and *q*, one round and one hexagonal. The round knob *p* controls the movement of the table in the same way as the knob of the single switch. The hexagonal knob *q* controls the operation of the motor *r*, which is used to raise or lower the cross-rail and

to give a traverse motion to the heads on the cross-rail. When either of the knobs *p* and *q* is pushed up, the driving motor *a* is stopped. When both are pushed up, the round knob *p* can be used to move the table slowly in either direction, and the knob *q* may be turned to operate the motor *r*. But the knob *q* cannot be used while the table is being driven under control of the master switch *b*. The motor *r* will give traverse to the heads when the lever *s* on the controller is thrown over to *t*, and it will move the cross-rail when the lever *s* is thrown over to *u*.

VARIABLE-SPEED DEVICES

27. Changing Pulleys to Vary Speed.—If a planer has but one speed and it must be temporarily increased or decreased for some special class of work, a larger or smaller pulley is sometimes placed on the line shaft in place of the regular driving pulley. The regular pulley is meanwhile moved along on the shaft and secured. The change in the size of the pulleys also requires a difference in the length of the driving belt. The driven pulley on the countershaft is not changed. The *line shaft* is the main shaft from which power for operating a machine is taken. A *countershaft* is an intermediate shaft between the line shaft and the machine for determining the speed at which the machine will run and having a clutch or else tight and loose pulleys by use of which the machine is stopped or started.

28. Variable-Speed Countershaft.—Changing the speed of the table by changing the pulley on the countershaft is slow and inconvenient. A simpler and quicker way is to use a variable-speed countershaft, one form of which is shown in Fig. 15. The shaft *a* carries the pulley *b* and the cone pulley *c*. The pulley *b* drives the belt that gives the table its return stroke. A short shaft *d* parallel to the shaft *a* carries the cone pulley *e*, to one end of which is fastened the small pulley *f*. The pulley *e* is set so that its small end is in line with the large end of the pulley *c*, and a belt *g* connects these two pulleys. The slack in this belt is taken up by the roller *h*, which presses against the belt and so holds it to the pulleys. The small pulley *f* drives the planer on its cutting stroke, and the speed of this stroke may

be changed by shifting the belt *g*. To increase the speed, the belt is shifted toward the larger end of the cone pulley *c*, and to decrease the speed it is shifted in the other direction. The roller *h* is first raised by pulling the cord *i*, and then the cord *j* or the cord *k* is pulled, according as the speed is to be increased or decreased. The cords *j* and *k* are connected to the bar *l* carrying the fork that shifts the belt on the cone pulleys. After the belt has been shifted, the roller *h* is allowed to fall back into place. Four different cutting speeds may be obtained by using

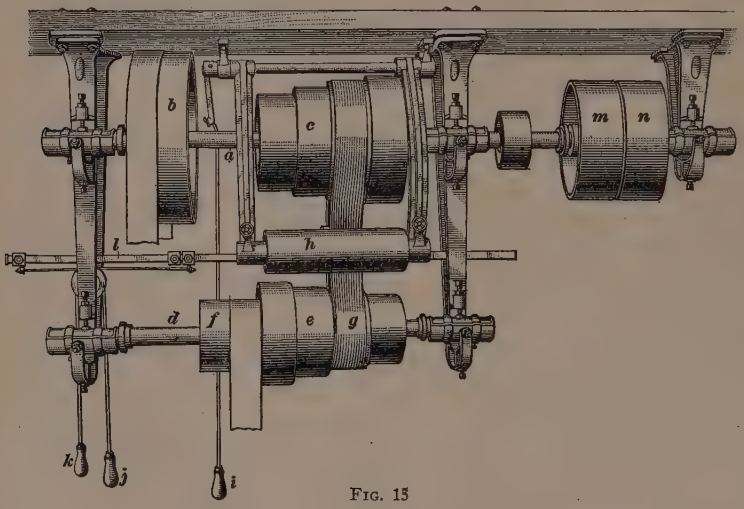

FIG. 15

this device. The shaft *a* is extended to a third bearing and is driven at a constant speed from the line shaft by a belt on the pulley *m*. A loose pulley *n* carries this belt when the shaft *a* is not running. Some makers supply a two-speed countershaft that gives two rates of cutting speed and a constant return speed.

29. Variable-Speed Gearing.—The cutting speed of a planer may be altered by the use of variable-speed gearing such as that shown in Fig. 16. The bull wheel *a* receives motion from the pinion *b* through the gears on the intermediate shafts *c* and *d*. On the return stroke, the driving belt is on the small pulley *e* fast on the shaft *f*, and the gear *b* is thus driven direct. During the cutting stroke, the driving belt is on the pulley *g*,

which is tight on the hub h to which the gear i is fixed, but loose on the shaft f. The gear i drives the gear j fixed to the shaft k, on which are two pairs of gears l, m, and n, o. These pairs of gears are arranged so that they may be moved along the shaft k by the shifting rods p and q, but must turn with the shaft. The four gears r, s, t, and u are keyed firmly on the shaft f. In the

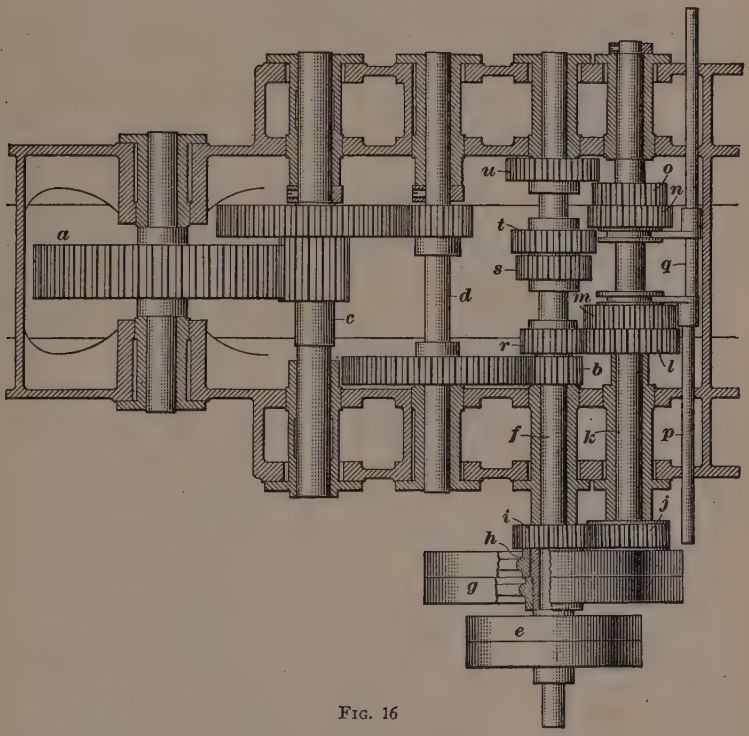

FIG. 16

position shown, the gears l and m are shifted by the rod p so that the gear l meshes with the gear r and the shaft f is then driven from the pulley g through the hub h, gears i and j, shaft k and gears l and r, thus turning the gear b and giving a slow motion to the table. By shifting the gear m into mesh with the gear s, a slower speed is obtained, and a still slower speed when the gears n and t are in mesh. The least cutting speed is obtained when the gear o is shifted to mesh with the gear u.

PLANER FEED-MECHANISM

30. Feed-Friction.—The feed-motion of the planer is usually obtained from the feed-friction, which is on the outer end of the shaft carrying the pinion that drives the bull wheel. The feed-friction and its connecting parts are shown in Fig. 17. It consists of an inner hub keyed to the shaft and surrounded by a friction band carried by the outer case *a*. Tension springs between the ends of the band hold it in contact with the hub, and when so held, the case *a* must turn with the hub and the shaft. Between the ends of the band is the squared end of the lever *b*, which is fulcrumed on a pin carried by the case *a* and extends outwards, as shown, between the stops *c* and *d*. The inner faces of the front and rear plates of the case are faced with leather that is held in sliding contact with the sides of the hub by three tension springs and bolts. As the shaft rotates in one direction, the grip of the band on the hub turns the case *a* through a part of a revolution until the lever *b* strikes one of the stops. This causes the lever to swing on its fulcrum and its squared end then forces the ends of the band apart, releasing the grip of the band on the hub and thus stopping the rotation of the case, which stops the feed. The leather facings now hold the case in its position until the table completes its travel.

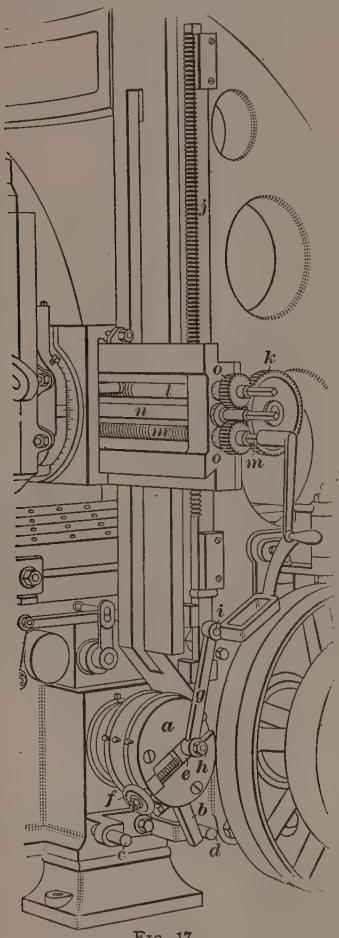

FIG. 17

As soon as reversal occurs, the lever moves from the stop, the band grips the hub, and the case is turned in the opposite direction until the lever strikes the opposite stop.

31. In the outer face of the flange *a*, Fig. 17, is a long slot in which is an adjusting block *e* that may be moved in the slot by turning the wheel *f*. One end of the rod *g* is connected to a pin *h* on the block *e* and the other end to a pin *i* fixed in the lower end of the vertical feed-rack *j*. Therefore, as the flange *a* is turned to and fro by the gripping and loosening of the band fastened to the lever *b*, the pin *h* is swung up and down, and the rack *j* is moved up and down in the slides. The rack meshes with a pinion on the inner end of the shaft that carries the gear *k*, so that the gear *k* is rotated first in one direction and then in the other. By moving the block *e* farther from the center of the flange *a*, the movement of the rack and of the gear *k* is made greater. The motion of the gear *k* may be transmitted to the cross-feed screws *l* and *m* or to the feed-rod *n* by the trigger gears and ratchets shown at *o*.

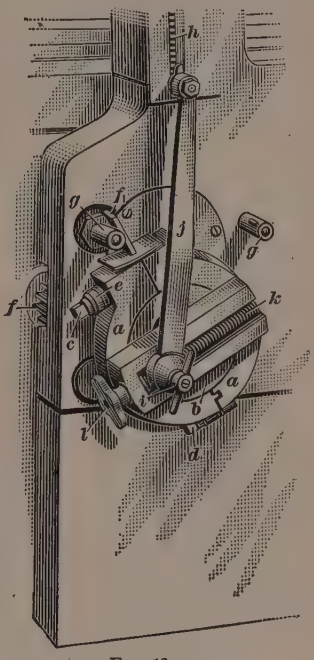

FIG. 18

32. Details of Feed-Friction. A feed-friction slightly different from that in Fig. 17 is shown in Fig. 18. A two-part collar *a* is fitted around a hub *b* and its parts are held loosely together by the screws *c* and *d*. A coiled spring *e* is used on the screw *c* to give the friction required between the collar and the hub. A gear *f* on the bull-wheel shaft drives a gear on the hub *b* and thus the hub *b* and collar *a* revolve back and forth together, and this motion is used to turn the feed-screws. There is a short lever f_1 located between the ends of the two parts of

the collar at the screw c, and two stops g set in the housing limit the distance that the lever f_1 can be carried around the hub by the collar. When the lever f_1 strikes a stop g it pries the ends of the collar apart against the action of the spring e and releases the collar from the hub. When the hub reverses, it carries the collar with it until the lever f_1 strikes the other stop g. The feed-rack h is moved up and down by the crankpin i and connecting-rod j, and the amount of the movement of h depends on the location of the pin i on the screw k, this adjustment being made by the hand wheel l on the screw k.

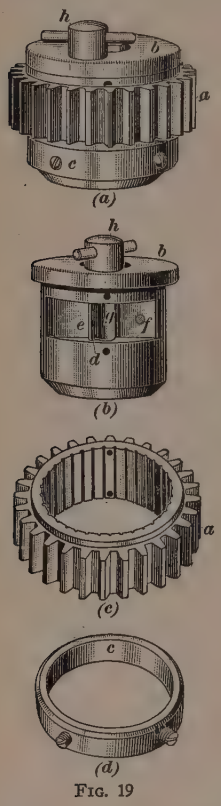

FIG. 19

33. Trigger Gear.—The trigger gear is simply a small gear and ratchet that is slipped on the end of the cross-feed screw or the feed-rod to cause it to turn continually in either direction as desired. The gear k, Fig. 17, rotates first in one direction and then in the other, but the screws l and m or the rod n are to turn in only one direction. The construction of the trigger gear that enables this to be done is shown in Fig. 19, in which (a) is a view of the complete gear, and (b), (c), and (d) show the three main parts. The gear a is a ring having teeth on the outside and notches on the inner face. The body b slips into the gear a and is held by the collar c. There is a slot in the body b, in which is a pawl d that has two ends or wings e and f. This pawl is fixed on a short shaft g that has a handle h on the outer end.

34. The central part b, Fig. 19, of the trigger gear slips over the end of the cross-feed screw or the feed-rod, and the teeth of the gear a mesh with those of the gear k, Fig. 17. When the handle h, Fig. 19, is in the middle position shown, the ends e and f of the pawl do not extend beyond the slot, and when in this position the gear a would simply turn back and

forth on the part *b*, when driven by the gear *k*, Fig. 17. By turning the handle *h*, Fig. 19, one end of the pawl may be set out so that it will catch in the notches in the inner face of the gear *a*, when the latter rotates in one direction, but will slip over them when the gear rotates in the other direction. As there are two ends to the pawl, it may be set to drive the screw or the feed-rod in either direction. The feed-motion is stopped by simply turning the handle *h* until neither end of the pawl engages with the gear.

35. Down Feed.—The down feed of the heads carried on the cross-rail is obtained from the feed-rod *n*, Fig. 17. The trigger gears *o* are slipped off the ends of the screws *l* and *m* and one is slipped on the end of the feed-rod *n*, which is then driven by the gear *k*. This change of the gear *o* makes it impossible to throw in the cross-feed and the down feed at the same time. The feed-rod *n* is splined and turns a bevel gear in the back of the saddle. This bevel gear, shown at *s*, Fig. 6 (*c*), drives a second one that turns the bevel-gear nut *t*, view (*b*), and moves the down-feed screw *k* and the slide *i*. The down feed is usually operated immediately after the reversal of the table for the cutting stroke.

36. Ratchet Feed.—In order to move the heavy tool heads and give the wide feeds commonly used on the largest planers, a ratchet feed is sometimes used instead of the friction feed previously described. The ratchet feed cannot slip under a heavy load. The location of the ratchet-feed box is shown at *v* in Fig. 14, and its mechanism in Fig. 20. It has four main parts, *A*, *B*, *C*, and *D*. The part *A* is bolted to the frame of the planer over the shaft that drives the ratchet mechanism. The hub of part *B* fits freely into the bore of the part *A*, and the hub *C* of the ratchet wheel *a* has a running fit in the bore of part *B*, and it is keyed to the reciprocating driving shaft, so that the ratchet wheel gives the feed-motion. The part *D* is attached to the face of the part *B*, and encloses the ratchet wheel *a* of part *C*. The part *D* is the cover-plate that carries the adjustable crankpin for moving the connecting-rod that transmits the crank-motion to the feed-rack screws.

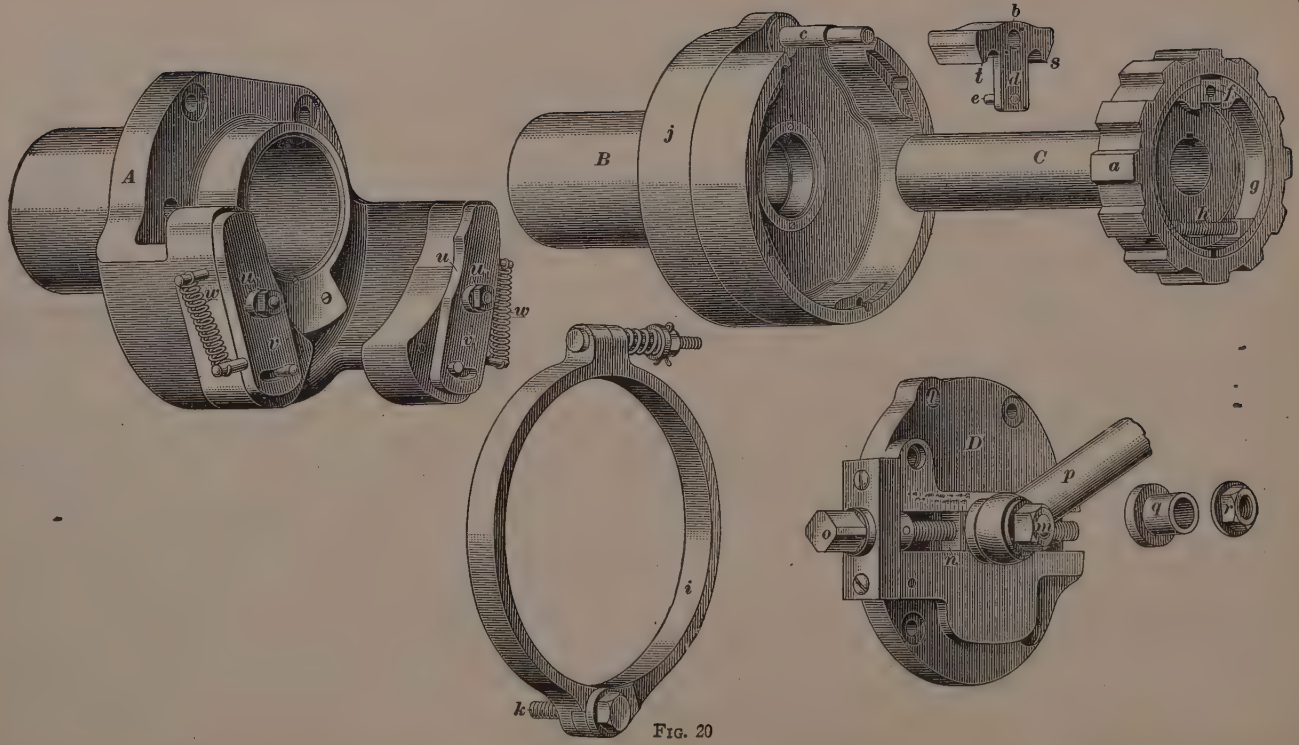

FIG. 20

37. Operation of Ratchet Feed.—The operations of the assembled parts *A*, *B*, *C*, and *D*, Fig. 20, of the ratchet-feed box are as follows: The ratchet wheel *a* derives its reciprocating motion from the gearing system that drives the planer table. The motions of the ratchet wheel *a* are transmitted to the part *B* by means of a double-ended pawl *b*, which is mounted on the

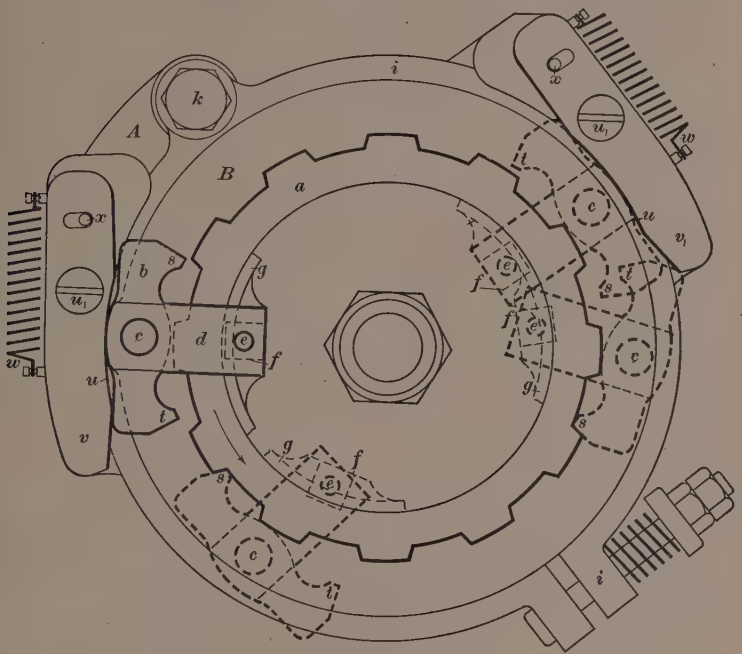

FIG. 21

stud *c* attached to part *B*. The pawl *b* swings on the stud *c* and its ends engage alternately with the teeth of the ratchet wheel *a*. Also, the pawl *b* has a flat lever *d* with a pin *e* projecting from the rear side as shown. The pin *e* enters the hole in the block *f* that slides between the ends of a two-part friction ring *g* on the inside of the ratchet wheel. The purpose of the friction ring *g*, whose light force is regulated by the spring *h*, is to steady and control the movement of the pawl *b* in its swing in changing from end to end in the teeth of the ratchet wheel. In order to steady the reciprocating motion of the part *B*

derived by means of the pawl b from the ratchet wheel a, a brake band i is set on the end j of B, and its hingebolt k is set into the part A. The cover-plate D is attached to the part B by means of four cap bolts, its hole l fitting over and supporting the outer end of the stud c. The crankpin m is set in a nut n and may be given any desired throw across the face of D by means of the screw o. The connecting-rod p fits over a sleeve q and is held on by a nut and washer r.

When the pawl b is located so that the center line of its lever d is radial, as shown in the left-hand view drawn in solid lines in Fig. 21, both the ends s and t are free from the teeth on the ratchet wheel a, and part B does not rotate. This condition takes place when the part B is revolved until it so locates the pawl b that the curved surface of its top fits the curve u on the inside of the latch v.

The return motion of the ratchet wheel, as shown by the arrow, drags the pawl, by means of the lever d, which has its pin e in the friction ring g, from under the latch v, and moves the trailing end s of the pawl into a groove on the ratchet wheel. This forces the part B to revolve. The rotation of part B continues until the pawl is forced into a radial position under the second latch v_1, as shown in dotted lines. The latches swing on a pin u_1 and are held against the back of the pawl by the tension springs w. Also, there is a pin x through the curved slot in the lower part of the latches for the purpose of limiting their swing. Thus the forward and backward rotations of the ratchet wheel a are transmitted to the parts B, Figs. 20 and 21, and D, Fig. 20, the stopping and starting of parts B and D being performed by the two latches v and v_1, Fig. 21, acting on the pawl b.

38. Rapid Power Traverse.—It is a great convenience to be able to move the heads and the tool slide by power, as well as to set them at any locations on the rail more rapidly than is possible by their feeds. The mechanism of a rapid power traverse is shown in Fig. 22 (a) and (b), these being front and back views, respectively. The vertical shaft a is driven at constant speed by the motor. Keyed to the shaft is a sleeve clutch b that may be moved up or down by the handle c so as

to engage with the bevel gear *d* or the bevel gear *e*. The handle *c* is connected to the clutch by the rod *f*, the bell-crank *g* and the rod *h*. In the neutral position shown, the clutch is free from both gears and no motion is transmitted from the shaft *a*.

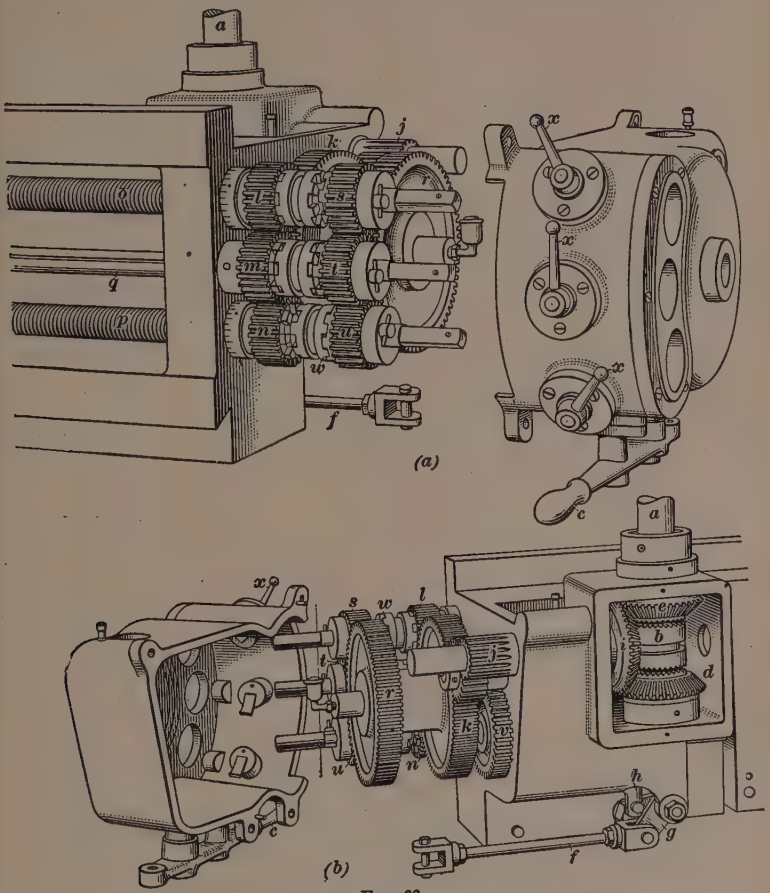

FIG. 22

When the clutch is engaged with the bevel gear *e*, power is transmitted from the shaft *a* to the bevel gear *i*, which is on the same shaft as the pinion *j*, and thence through a train of gears to the planer heads. When the clutch is shifted to engage with the bevel gear *d*, the resulting movement of the heads is reversed.

39. The pinion *j*, Fig. 22 (*a*) and (*b*), drives the large gear *k*, which is so placed as to mesh with the three small gears *l*, *m*, and *n*. The gears *l* and *n* are on the feed-screws *o* and *p* and the gear *m* is on the feed-rod *q*. There is a second train of gears similar to the one just described, consisting of a large gear *r* meshing with the small gears *s*, *t*, and *u* on the feed-screws and feed-rod. This second train is driven from the pinion *v*, which is larger than the pinion *j*, and therefore runs at greater speed. There is a double-ended jaw clutch *w* between each pair of gears *l* and *s*, *m* and *t*, and *n* and *u*, and the clutch may be thrown into gear with either of the two gears by moving the handle *x*. In one direction, movement of the clutch produces slow speed and in the other direction it gives high speed to the feed-screws or feed-rod. In the neutral position, no motion results. Thus it is possible to stop the screws and the rod separately or all at once.

PLANER ADJUSTMENTS

40. Errors in Planer Table.—The effect of the driving in of stop-pins, the pull of clamp bolts, and the careless handling of work is to peen the top of the planer table and stretch it, causing it to spring upwards at the middle. Also, in old types of planers, in planing long work, the table extends over the ends of the bed and its ends drop down, so that the work produced is not true. The table must then be trued, which may be done by taking a few light cuts across it. The first cut should not be so deep as to extend the whole length of the table; for if it is, there will be so much metal removed that the table will slowly spring back to its former shape as the cutting proceeds, and by the time the tool has been fed across, the edge at which the cut was started will be low in the middle. One or more light cuts will then be necessary to finish truing the table.

41. Error in Cross-Rail.—The cross-rail must be tested to see that it is level with respect to the V's, before a table is trued or any broad surface is planed. If it is not true, the table will be thicker at one edge than at the other. To test it, the

table should be run back, as shown in Fig. 23, to uncover the V's under the cross-rail. The V's are wiped clean, and one of a pair of short rolls or mandrels *a* of the same diameter is placed in each V. A square-nosed tool *b* that has previously been set flat on the table is adjusted over one roll until a feeler gauge will just pass between it and the roll. The head *c* is then moved over to the other roll and the test is repeated. When the feeler is held with the same pressure on each roll, the rail is set correctly; if not, some adjustment must be made. A dial gauge is a convenient tool for making this test.

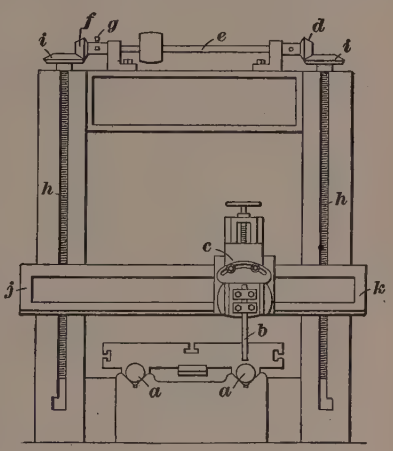

FIG. 23

42. Adjustment of Cross-Rail.—In the planer shown in Fig. 23, the pinion *d* is firmly pinned to the elevating shaft *e*, but the pinion *f* is held by a setscrew *g*. The elevating screws *h* have the same pitch and the bevel gears *i* are the same size; so, when the shaft *e* turns, both ends of the cross-rail move the same distance. If the cross-rail is found low at one end, that end must be raised. To do so, the setscrew *g* is loosened. Then, if the end *j* is low, the pinion *f* is turned so as to lift it to the same height as the end *k*, after which the setscrew *g* is tightened. If the end *k* is low, the shaft *e* is turned until the end *k* is at the height of the end *j*, and the setscrew is tightened. After making these adjustments, the rail should be raised about $\frac{1}{4}$ inch, to take up all backlash, and should be given a final test. Planers of other makes may have other ways of adjusting the height of the cross-rail, and the workman should become familiar with the methods used on the machine he is operating.

43. Testing Planer Beds.—Large planers should be set on concrete foundations and the beds should be carefully leveled

both crosswise and lengthwise. For crosswise, the table is tested with an erecting level that is laid across it in front of the housings. The table is then run to each end of the bed and tested in these positions. For accurate checking, the table should be removed; then two rollers, ground to exactly the same diameter, should be laid in the ways, as shown at *a*, Fig. 23, after which a level should be used on a parallel straightedge laid across them.

44. Next, the bed is tested lengthwise to see whether the ends are level with the middle of the bed. Long planer beds

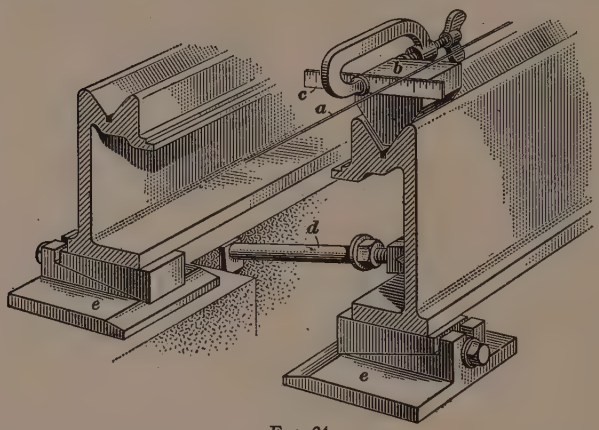

FIG. 24

are tested lengthwise as in Fig. 24. A fine wire *a* is stretched tightly above one of the ways, in such a position that it is directly above the center of the way at each end. This can be assured by the use of a block *b* made to fit the way and having a steel rule *c* clamped to it. The block is then moved along the way, and the point at which the wire *a* crosses the scale is observed. If the way is straight, the same graduation will be under the wire throughout the whole movement of the block from end to end. If it is not straight, the amount of sidewise deviation is easily determined from the scale. If the bed is out of line sidewise, a jack *d* may be placed against it, as shown, to force it back into line. If the bed is found to be low at points, it should be wedged up at those points with metal wedge blocks *e*.

LUBRICATION OF PLANERS

45. General Remarks.—The outside and overhead mechanism of a planer should be well lubricated with a good grade of machine oil. The oil may be fed from individual cups filled by hand; or the oil may be distributed to the separate bearings through small pipes from a central reservoir. A wick placed in the end of each pipe and dipping into the oil reservoir acts as a filter and insures the delivery of clean oil. The transmis-

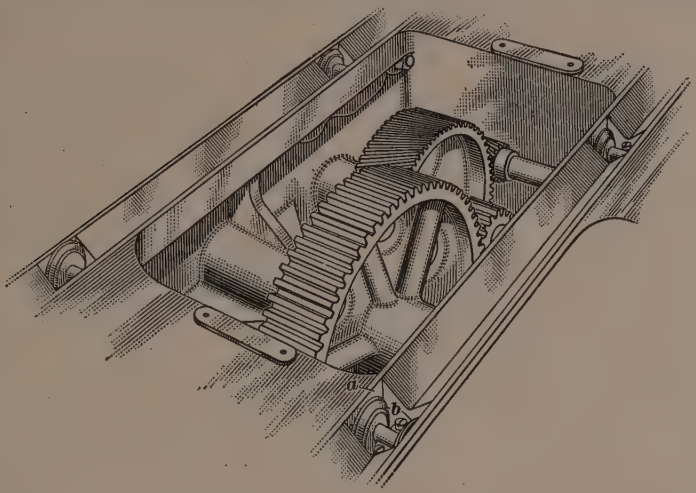

FIG. 25

sion gears are usually enclosed in casings and are run in a bath of oil or light grease.

46. Oiling Ways and V's.—The ways and **V**'s of a planer should be lubricated with cylinder oil or other heavy oil, because of the great pressures to which they are subjected. In some planers, oil pockets are cast in the ways, as at *a*, Fig. 25, in which are double conical rollers *b* that rest on springs which force them up against the **V**'s of the table. The movement of the table rotates the rollers, and as they dip into the oil in the pocket, they carry oil up and spread it over the **V**'s, by which it is carried along the ways. A further aid in distributing the oil is furnished by oil channels cut in the faces of the **V**'s.

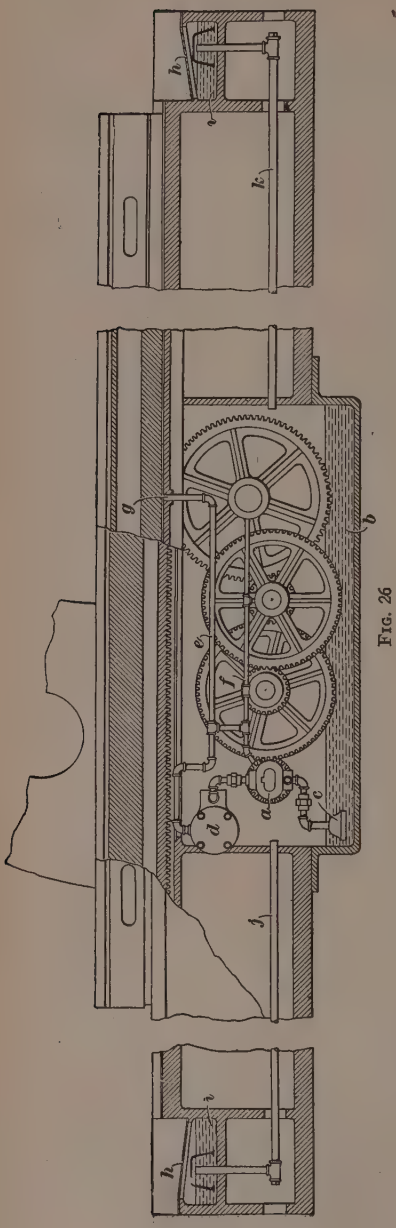

FIG. 26

47. Force-Feed Lubricating System. — A system of force-feed lubrication for oiling the parts beneath the table, such as the **V**'s, ways, shaft bearings, and gears, is shown in Fig. 26. A reversible pump *a*, driven from the drive gearing of the planer, draws used oil from the reservoir *b* in the bottom of the bed through a strainer and a check-valve at *c*, forces it through the filter *d*, and thence into the delivery pipe *e* to the ways and into the pipe *f* to the bearings. The flow of oil is controlled by a pressure relief valve, not shown, which insures enough oil during the cutting stroke and prevents an excessive amount during the rapid return stroke. The pump and all the piping except the pipes *e* and *f* are located outside the bed, so as to be inspected and cleaned readily. The outlet *g* of the pipe *e* is at the center of the bed and supplies oil to the channels cut in the **V**'s. The used oil collects at the ends of the ways, and flows through strainers *h* into basins *i*, from which it is led through pipes *j* back to the reservoir *b*.

48. Lubricating Loose Pulleys.—Planer pulleys run at high speed, and the loose

pulleys rotate in opposite directions to their shafts, so that it is difficult to keep the pulley bearings properly oiled. Self-oiling bronze bushings are largely used for these bearings, a simple form of such bearing being shown in section in Fig. 27. The bronze bushing *a* is pressed into the hub *b* of the pulley and turns with it. A number of felt plugs *c* fill holes drilled through the bushing and bear against the shaft on which the pulley turns. Between the ends the bushing is turned to a smaller diameter, leaving a recess *d* that forms a chamber for oil or grease

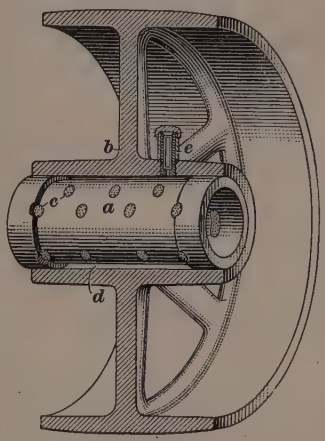

FIG. 27

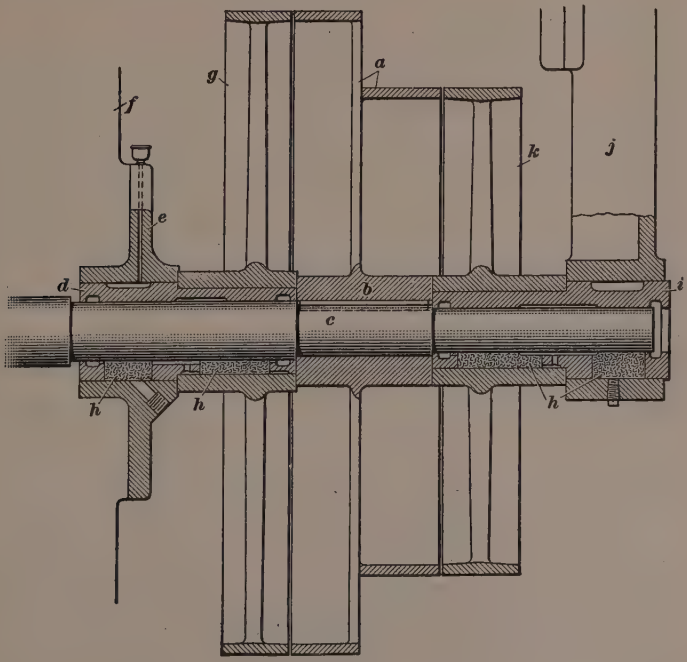

FIG. 28

fed by the compression cup *e*. The lubricant passes through the felt plugs and is thus distributed over the bearing. Sometimes the plugs are saturated with graphite before they are inserted in the bushing.

49. In the form of bearing shown in Fig. 28, the bushing is stationary and the loose pulley runs on the outside of it while the shaft turns inside it, so that the speeds of the rubbing surfaces are greatly reduced. The aluminum tight pulleys *a* are cast together, with a single hub *b* that is keyed to the drive shaft *c*. A stationary bronze bushing *d* is set in the collar *e* held in the housing *f*, and supports the drive shaft *c*. The inner loose pulley *g* turns on the outside of the bushing. Felt blocks *h* held in slots in the bushing distribute oil to both the shaft and the pulley bearing. A similar construction is used at the outer end of the shaft *c*. A stationary bushing *i* held in the arm *j* supports the shaft and the loose pulley *k* turns on the outside of the bushing.

OPEN-SIDE PLANER

50. General Construction.—The open-side planer, shown in Fig. 29, is intended to be used for work that is too wide or too irregular for the ordinary planer. It consists of one heavy upright *a* attached to a bed *b* that carries the table *c*. This table is usually made somewhat heavier than would be the case with an ordinary planer having the same width. The cross-rail *d* is supported from one end only by the housing, or post, *a*. A heavy brace is fitted between the back end of the upright and the outer end of the cross-rail *d* to make the cross-rail as stiff as that ordinarily supported by two housings.

51. One or more planer heads *e*, Fig. 29, are carried on the cross-rail and a side head *k* on the upright. An auxiliary rest *f* is provided, which runs on a series of rollers *g* on the top of the **I** beam *h* to support the end of work that overhangs the planer table. The **I** beam supporting the rest can be moved toward or away from the planer bed by adjusting it along the supports *i*. Both the bed and the supports for the rest should

be placed on the same rigid foundation. The table is usually driven by a spiral gear. The cross-rail of the open-side planer is raised and lowered by two elevating screws, as in the ordinary planer, one screw lifting the cross-rail proper and the other the rear end of the brace.

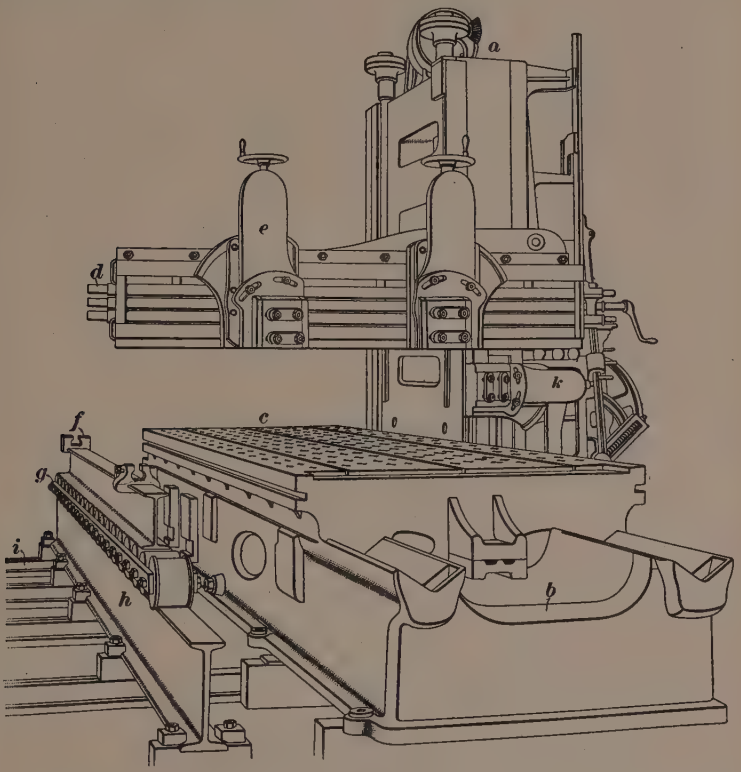

FIG. 29

52. Floor Stands.—Some open-side planers are provided with a detachable housing, or floor stand, that is used when the planer is working on ordinary work and that is removed when the work is too wide to pass between the housings. The floor stand gives additional stiffness to the cross-rail. Floor stands are also used to plane work too wide for the double-housing planer. Two types of floor stands are illustrated in Fig. 30, that in (*a*) resembling the housing and cross-rail of an open-

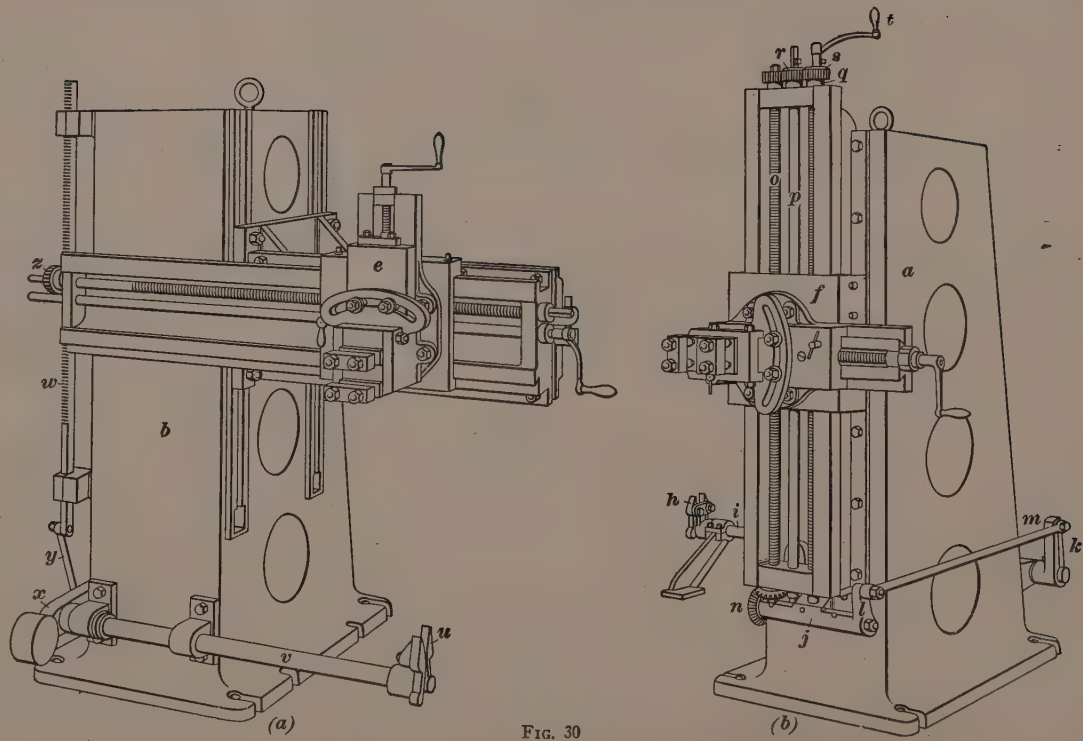

FIG. 30

side planer, and that in (*b*) being intended for planing vertical surfaces. These floor stands are bolted to a slotted floor plate, one on each side of the table, in front of the cross-rail, and as far apart as the width of the work may require. The feeds and traverse motions may be operated by either hand or power. If power is used, the trip is actuated directly from the planer or by an extension of the dog on the table. Some of the details of these floor plates are as follows: The stands *a* and *b* are box-shaped for strength and lightness, and have flanged and slotted bases suitable for easy attachment to the floor plates. These stands are provided with screw eyes in the top so that they may be hooked up by a crane. The tool heads *e* and *f* are similar to those used on the regular planers previously described. The trips *h* and *u* that operate the power feeds are moved back and forth by extension stops or dogs clamped to the side of the planer table. In (*b*) the trip *h* is on a shaft *i* that has an arm *k* on its opposite end, which transmits its motion by a rod *m* to an arm *l* on the front of the stand. The motion of *l* revolves the bevel gears *n*, a ratchet in the support *j* being used to give the direction required of the two feed-screws *o* and *q*. Power feed horizontally is made by the rod *p*, which has a gear *r* meshing with those on the vertical feed-screws. Hand feeds are operated by the handle *t* and gear *s*.

In (*a*) the trip *u* gives a short rotation to and fro of its shaft *v*, which has an arm on its outer end that moves the feed-rack *w* up and down by means of the connecting-rod *y*. A counterweight *x* balances the weights of the rack and the moving connections. The cross-feed is by means of the feed-screw and ratchet gear *z*, and the down feed of the head *e* may be given either by the geared feed-rod or by the hand crank.

MAINTENANCE OF PLANERS

CARE OF PLANERS

53. Lost Motion and Wear.—The various parts of the planer should always be kept adjusted so that there is no lost motion. The screws in the gibs of the down-feed slide and of the cross-rail should be kept tight, so that the slide and the planer head will have no shake or lost motion. The pawl or the ratchet of the feed-mechanism may become so worn that it slips or will not work, and it should be kept in good repair. The table and the cross-rail should be tested and inspected frequently to make sure that they are in condition to produce true work.

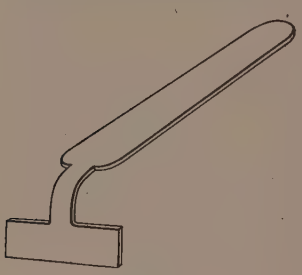

FIG. 31

54. Removal of Chips.—The chips are usually swept off the table with a brush or a broom, after the work is removed. Those that fall into the **T** slots and become packed there may be loosened with the blunt tang of a file and then swept out with a scraper of the form shown in Fig. 31, which has a handle several inches long and is made of sheet steel $\frac{1}{8}$ inch thick. Sometimes the chips get packed between the teeth of the bull wheel to such a depth that they cause the table to rise off the ways. The table must then be run back and the spaces between the teeth must be thoroughly cleaned.

55. The **V**'s should be protected from flying chips and dust by broad boards extending out from the table over the **V**'s in the bed. If there is a considerable length of the **V**'s uncovered by the table while running on a short stroke, board covers are placed on the **V**'s. The **V**'s of old planers sometimes wear so that the bull wheel bottoms in the table rack and causes the table to ride and vibrate. This is corrected by taking the rack off and planing down its back.

PLANER EQUIPMENT

CHUCKS

56. Swivel Chuck.—The planer chuck forms a very useful and time-saving device when work is to be planed that is so small or irregular in shape that it cannot conveniently be fastened directly to the table. A type of swivel chuck is shown in Fig. 32. The base is a split clamping ring *a* that surrounds and grips the graduated circular plate *b*, which is in one piece

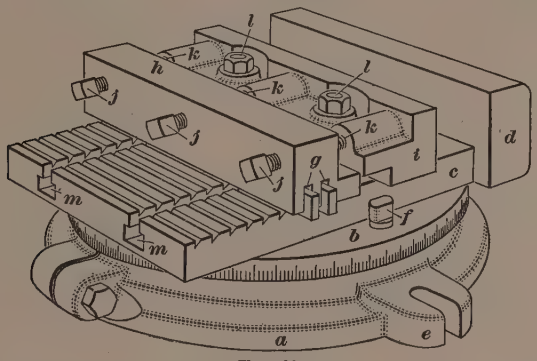

FIG. 32

with the body *c* of the fixed jaw *d*. A slotted lug *e* on each side of the clamping ring enables the chuck to be secured to the table by bolts in the T slots. The taper pin *f* serves to locate the jaws parallel to the slots in the lugs *e*, and the clamping ring *a*, when tightened, holds the body *c* in any intermediate position. The top face of the body *c* contains a number of crosswise slots in which steel tongues *g* may be inserted to square up the backing block *h*. The movable jaw *i* is set up by the screws *j* so as to hold the work, these screws bearing against hardened steel plugs *k*. Two bolts *l* with heads that fit in the slots *m* clamp the adjustable jaw to the body *c*.

57. Magnetic Chuck.—The magnetic chuck, Fig. 33, is a convenient device for holding some kinds of work on which light cuts are to be made. It consists of a plate *a* that is held

firmly to the planer table *b* by clamps and bolts, as at *c*. On the flat top the pieces of work *d* are laid, and when the switch *e* is closed the electromagnets inside the chuck hold the work down. The raised strip *f* and the stops *g* prevent sidewise motion and the stop-plate *h* prevents endwise motion. When the switch *e* is opened, the magnetic force ceases and the work may be lifted from the chuck. The face of the chuck consists of a number of positive pieces, or poles, *i* and negative pieces *j* arranged alternately, and separated by brass or other nonmagnetic material, as indicated by the heavy lines. To be held firmly the work should be placed on the chuck so that it will extend

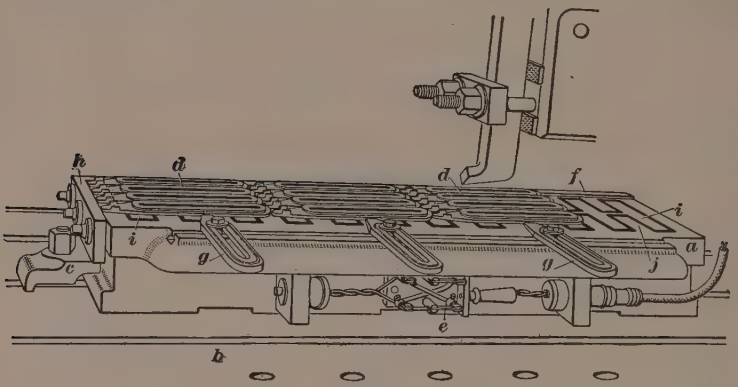

FIG. 33

over at least one positive and one negative piece. The use of the magnetic chuck enables frail pieces of work to be secured quickly and easily, without springing. However, only iron and steel parts can be held directly by the magnetic chuck, although brass and other nonmagnetic parts may be placed in steel clamps that in turn may be held by the magnetic chuck. This form of chuck uses direct current only, one of its advantages being the ease and quickness with which it may be operated.

PARALLELS, V BLOCKS, SCREW PLUGS, AND STRIPS

58. Parallels and Parallel Blocks.—Parallels, which are pieces of cast iron or soft steel, are usually made in pairs and are planed accurately to the same dimensions. They vary from

4 to 16 inches in length and are of any convenient width and thickness, being often made square. If parallels are made in sets, the width and thickness increases by quarters, eighths, or sixteenths of an inch, as may be most convenient. Parallel blocks are short parallels and are from $\frac{3}{4}$ to 2 inches square. They may be made by cutting a long parallel into short pieces; or, flat rolled steel ground to within 1 or 2 thousandths of an inch of standard size may be cut into parallel blocks.

59. Cross-Parallel.—If a cut is to be taken crosswise of the work or at an angle to it, the work should be clamped against a cross-parallel, as shown in Fig. 34. The cross-parallel *a* is a strip of cast iron about as long as the table is wide, from 1 to 2

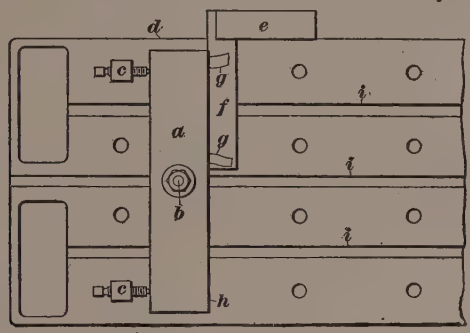

FIG. 34

inches thick, and from 3 to 4 inches wide. It is made larger than this for use on large planers. It should be planed true all over, and a hole should be drilled at the center for the clamp bolt *b*. The top surface and the face against which the screw plugs *c* bear may become dented, but the bottom and the face against which the work is held must always be kept true and free from dents.

60. Setting of Cross-Parallel.—The cross-parallel is first placed on the planer table with its working face toward the cross-rail, and the clamp bolt *b*, Fig. 34, is drawn up loosely. The screw plugs *c* are placed in two outer holes behind the cross-parallel, and the latter is then set square with the back edge *d* of the table by the use of a try square, as shown. The beam *e*

of the try square is held flat against the edge *d* and the blade *f* is brought up against the cross-parallel. Strips *g* of tissue paper are placed between the blade and the parallel, and the tightness with which these are held is tested by pulling them gently with the free hand. If one strip is tight and the other is loose, the set-screw in the proper plug should be tightened, and this should be repeated until both strips are held with the same pressure. The clamp bolt *b* is then tightened, and if the paper strips are still held evenly the cross-parallel is squarely set. A true side of the piece to be planed is then set against the working face *h* and the work is fastened by screw plugs and clamps. The back edge *d* and the back edges *i* of the slots are always trued when a planer is erected, and a piece of work may be lined or squared from them. A bevel protractor is used to set the cross-parallel when a cut is to be taken at an angle to the edge of the work.

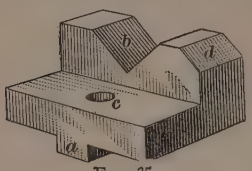

FIG. 35

61. V Blocks.—A form of **V** block used in planer work is shown in Fig. 35. It is an **L**-shaped casting having a tongue *a*

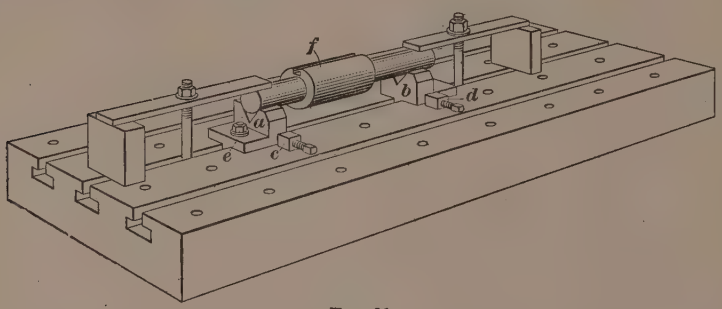

FIG. 36

on the under side of the base, parallel to the groove *b* in the upper edge. The tongue *a* fits into the **T** slot in the table and the planer bolt passes through the hole *c*. These blocks are generally used in pairs and it is a good plan to bevel one top corner of each pair, as shown at *d*, so that the workman will know at a glance whether they are properly located with respect

to each other. They are used for holding round work exactly level and parallel with the **T** slots in the planer table, as *shown* in Fig. 36. The tongues of the **V** blocks *a* and *b* are forced against the trued side of the **T** slot by the screw plugs *c* and *d* and are held firmly by the planer bolts *e*. A light truing cut is taken down the face of each **V**, and then the work *f* is placed so that parts of the same diameter rest in the grooves. The clamps should be put over the work at the **V** blocks. If a clamp is located at any point not directly over a **V** block, the work must be supported from beneath or it will be sprung out of shape. The angle of the groove in the **V** block is 90° for small work and 120° for large work.

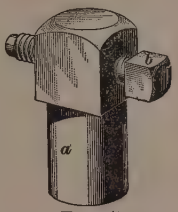

FIG. 37

62. Screw Plugs.—A screw plug for holding work to the planer table is shown in Fig. 37. It is made from a piece of square steel on which a round shank *a* is turned to fit the holes in the table. A hole is drilled through the square head, sloping downwards at an angle of about 5°.

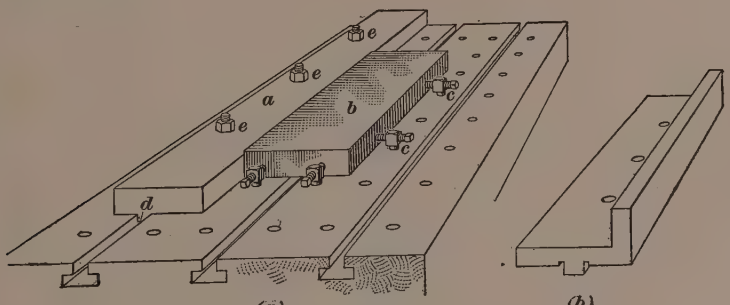

FIG. 38

63. Strips.—A strip is a piece of cast iron of convenient length having a rectangular or an **L** section and is used to prevent sidewise movement of a piece of work on the planer table, and also to line the work parallel with the table. The rectangular form is shown at *a*, Fig. 38 (*a*), and the piece of work *b* is held against it by the screw plugs *c*. The bottom of

the strip is planed true and is formed with a tongue d about $\frac{1}{4}$ inch high and from $\frac{1}{8}$ to $\frac{3}{16}$ inch narrower than the width of the T slot. A wedge, such as a cut nail, is driven at each end between the side of the tongue and the side of the T slot to force the strip against the opposite side of the slot, where it is held by tightening the nuts e. The L form of parallel strip is shown in (b). Instead of one long strip, two short strips may be used, one being placed near each end of the work. The piece to be planed is thus held parallel to the line of motion of the table.

64. A strip for holding round work in which a slot is to be planed is shown at a, Fig. 39. One side of the strip is planed

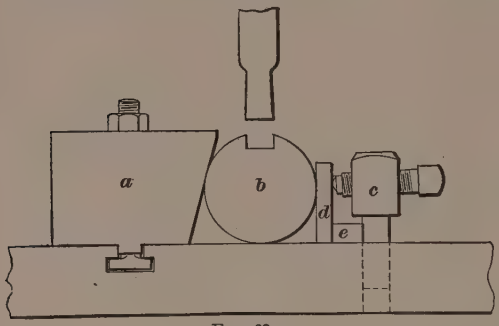

FIG. 39

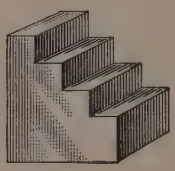

FIG. 40

so that it makes an angle of 15° or 20° with the vertical. The work b is placed against this slanting face and is held there by screw plugs c that are set just above the center. The setscrew bears against a packing piece d, so as not to dent the work, and a block e prevents the packing piece from tipping. If the setscrew bears at a point on a level with the center line of the work, the block e is not needed.

Before a strip is used for accurate work it should be trued. A cut is taken down its face with a side tool and this face is then tested with a try square. If the face is not square with the table, the head should be readjusted and truing cuts should be taken until the face is square with the surface of the table. When this has been done, work held against the strip will be planed square.

65. Step Blocks.—The forms of blocks shown in Fig. 40 are very useful in setting work on the table. They are made of various sizes, with different heights, widths, and heights of steps; thus, by turning the block on its side or its edge, or by using a convenient step, it can be made to accommodate a variety of heights.

STOP-PINS, THRUST BLOCKS, STAKES, AND ANGLE PLATES

66. Stop-Pins.—The stop-pin is used to prevent work from slipping under the pressure of a cut. As shown in Fig. 41 (*a*), it consists of a pin having a round shank *a* that will fit the holes

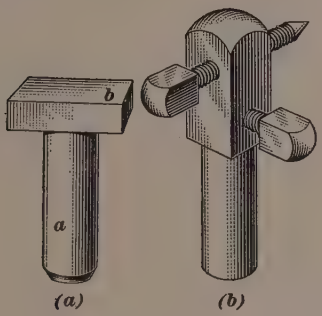

FIG. 41

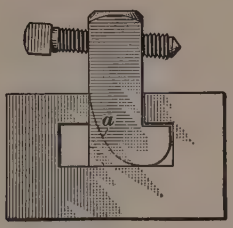

FIG. 42

in the planer table, and a square head *b* from $\frac{1}{4}$ to $\frac{1}{2}$ inch thick. Another form of stop-pin is shown in (*b*). It is drilled and tapped to hold two screws, so that it may be used against an inside corner of a piece of work, one screw bearing against one surface and the other screw against the other surface. It may also be used in other than corner positions, as the screw of the height best suited to the work may be used.

67. Thrust Blocks.—The thrust block, shown in Fig. 42, is a rectangular piece made to be slid into a **T** slot and having a shoulder at its lower end to prevent it from being pulled out of the slot. A setscrew is screwed through the top, and is slanted at a slight angle. Thrust blocks are used mainly on tables that have only **T** slots and no holes for plugs. If this block is to be inserted at any point along a **T** slot, instead of being inserted at

the end and then slid along the slot to the desired point, it must be rounded off at the back, as indicated by the outline *a*.

68. Stakes.—Stakes are used instead of stop-pins for holding large work. They are made either round or rectangular to fit the holes in the planer table and at the upper end are slightly larger than the hole, a shoulder being formed so that they cannot slip through.

69. Angle Plate.—An angle plate, shown at *a*, Fig. 43, is an L-shaped casting whose outer faces are planed true and at

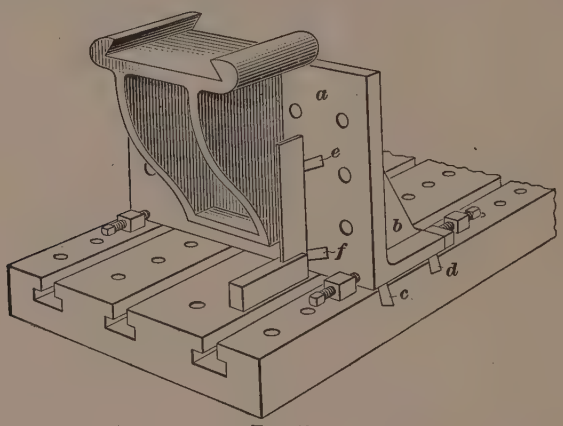

FIG. 43

right angles to each other. Ribs or webs *b* at the back brace the two sides, which are drilled with holes or slotted to receive bolts by which the angle plate may be held to the table and work may be held to the angle plate. A drilled plate is stronger than a slotted one. The angle plate is used to hold work that has two surfaces that are to be planed square with each other, or that has one side that is of such shape as to prevent it from being clamped directly to the table. It is usually set either parallel to the line of motion of the table or square with it.

70. Setting of Angle Plate.—Because of the severe treatment it receives, the angle plate does not remain true very long, and therefore it must always be set carefully. It is first set square with the table vertically, as shown in Fig. 43, the stock

of the try square being placed on the table and the blade against the angle plate. Strips of tissue paper are inserted under the base of the angle plate at *c* or at *d*, as required, to bring the upright part true against the try square, so that the paper strips at the opposite points *e* and *f* will be held with the same pressure. These operations must also be carried out at the other side of the angle plate. The angle plate is then set square with the back edge of the table, by the use of a try square in the same way as for setting the cross-parallel, and is clamped down, after which it is tested again, to make sure that it has not been moved by the clamping. The table must not project over the end of the bed while the angle plate is being set, as the spring or sag will result in a faulty setting. The working side of the angle plate should face away from the cross-rail, as shown, so that all springing will be away from the cutting tool and chattering will be prevented. If the work is large, the overhanging part should be supported by a bracket or jack so as to prevent its springing down from the pressure of the tool.

BOLTS, CLAMPS, AND TOE DOGS

71. Planer Bolts—When the work is too large to be held by screw plugs or by chucks, it is fastened by bolts and clamps.

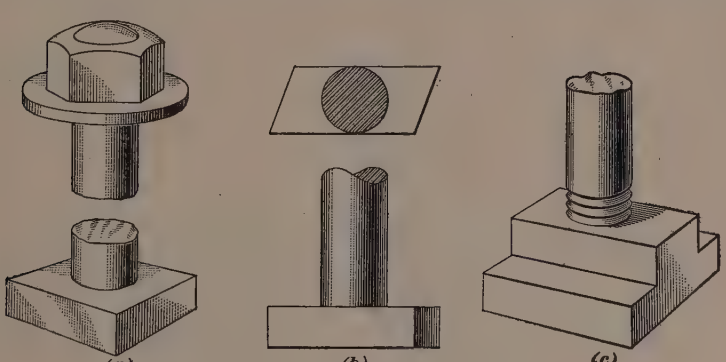

FIG. 44

The square-headed bolt shown in Fig. 44 (*a*) is the strongest form. The head is inserted into a **T** slot at the end of the table and the bolt is moved along the slot to the desired position. The

quarter-turn bolt shown in (*b*) has a narrow head that may be slipped into a **T** slot at any point, after which a quarter turn brings the ends of the head under the lips of the slot. The form

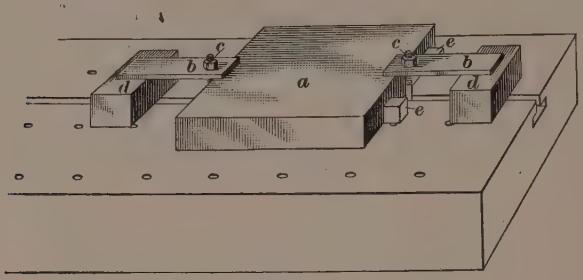

Fig. 45

shown in (*c*) consists of a nut that is slipped into the end of the **T** slot and is moved along to the required position, after which the bolt is put through the clamp and is screwed into the nut. If desired, a stud threaded at both ends may be screwed into the nut in the slot and a nut may be screwed on the upper end.

72. Flat Clamps.—The flat clamp consists of a piece of flat iron or steel stock of convenient length and 2 inches by $\frac{5}{8}$ inch in section, with a hole drilled through it near one end. The use of flat clamps is shown in Fig. 45, in which a piece of work *a* is held by clamps *b* and bolts *c*, the parallel blocks *d* being used to bring the clamps fairly level. Stop-pins *e* prevent slipping. The bolts should be as close as possible to the work, so that the greatest pressure is put on the work and not on the blocks; also, the blocks should be a little higher than the point where the clamp rests on the work. A piece of card under the end of the clamp will prevent it from injuring finished surfaces; also, a piece of smooth iron stock between the clamp and the work will give a better bearing. Drop-forged clamps of the form shown in Fig. 46 are very strong for their weight and are coming into use extensively.

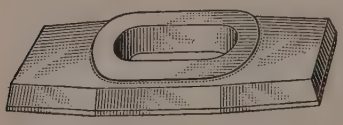

Fig. 46

73. Gooseneck and U Clamps.—The application of the gooseneck clamp is shown at *a*, Fig. 47. Because of its shape

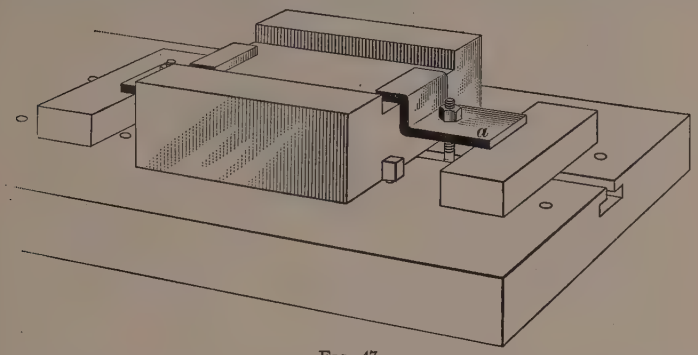

FIG. 47

a shorter bolt may be used than with a flat clamp, and it is also less in the way. The U clamp is a piece of square iron or steel bent to the shape shown in Fig. 48. The shank of the bolt

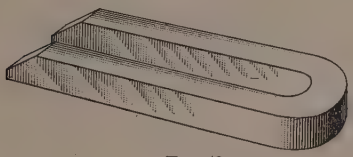

FIG. 48

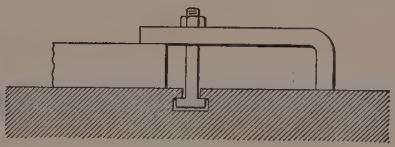

FIG. 49

passes through the slot between the arms and a washer under the nut forms a good bearing on the clamp. The bolt may be placed in any position in the slot.

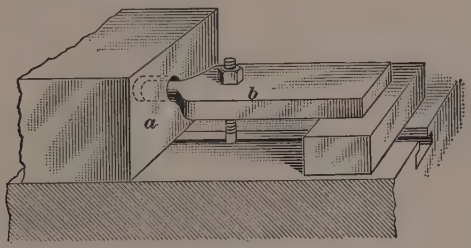

FIG. 50

74. Right-Angle and Finger Clamps.—The bent clamp shown in Fig. 49 does away with the use of a packing block, as the short end of the clamp is as long as the work is high. This

end should be machined so that it will rest squarely on the table. The holding-down bolt should be set close to the work. The finger clamp is shown in Fig. 50. The end that holds the work is drawn or turned to a cylindrical shape, and fits into a hole that is chipped or drilled in the work *a*. The other end *b* is like a flat clamp. Finger clamps are used to hold work that must be

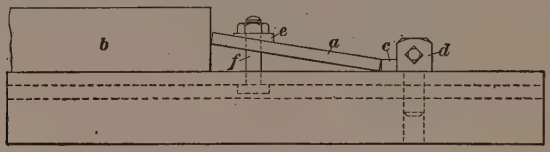

FIG. 51

planed over its entire top surface and that will not be damaged by drilling holes for the clamps.

75. Wedge Clamps.—If the work cannot be held by finger clamps and yet the holding devices must be kept below the surface of the work, wedge clamps may be used, as illustrated in Fig. 51. A flat clamp *a* is set so that one end rests against the work *b* at a point just below the upper edge and the other end butts against a cross-piece *c* that is held from slipping by screw plugs *d*. A washer *e* that is thicker at one side than at the other is placed under the nut of the planer bolt *f*, so that the nut is

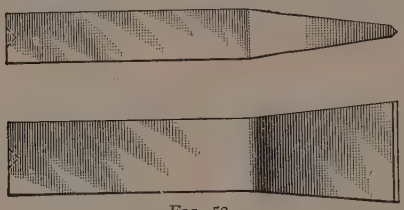

FIG. 52

level, and the nut is tightened. The clamp is thus wedged in firmly and the piece *b* is held securely.

76. Toe Dogs.—Thin work may be fastened to the table by the use of toe dogs in connection with screw plugs. The toe dog, as may be seen in Fig. 52, is a piece of steel from 2 to 4 inches long, with one end flattened to a chisel shape and the other end cupped to receive the setscrew of the screw plug. In

Fig. 53 a piece of thin work *a* is held by the use of a straightedge *b* and toe dogs *c*. The parallel *d* is grooved along one face to receive the back of the straightedge, and the work is gripped

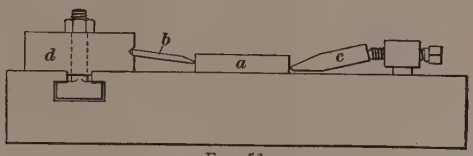

FIG. 53

by screwing up the setscrews against the ends of the toe dogs. If the work is long, more than two toe dogs should be used. The toe dogs should slant downwards, but not at too great an angle, or they will slip off the edge of the work. The thin end of the toe dog may be hardened, so that it will cut into the work to be held and thus be kept from slipping, but in many cases the end is rounded. If the face of the work is finished and it is not to be marred, a piece of sheet copper should be placed between it and the toe dog.

PLANER JACKS AND CENTERS

77. Planer Jacks.—The planer jack, illustrated in Fig. 54, is made in different sizes and is used to support work. It con-

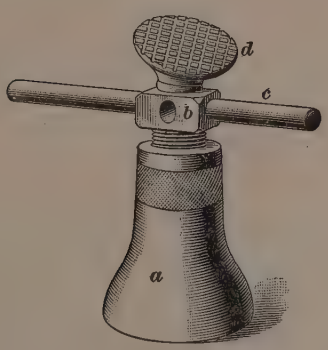

FIG. 54

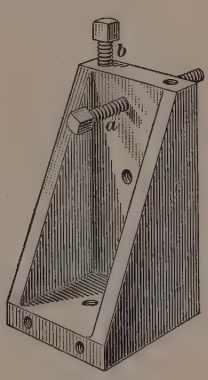

FIG. 55

sists of a body *a* in which is a screw *b* with a square head. Holes drilled through the head allow a bar *c* to be inserted so as to turn the head up or down. A cap *d* is fixed to the head

by a ball-and-socket joint, so that it can adjust itself to the surface of the work. The top of the cap is checkered so that it will not be so apt to slip. The special jack, or brace, shown in Fig. 55 is useful where screw plugs and stakes are insufficient and ordinary jacks cannot be used. It is a box-shaped casting of a size to suit the work, planed smooth on the bottom and on the front, so that either face may be laid against the table. No tongues are provided, and the jack is held to the table by bolts and screw plugs. Holes may be drilled and tapped in any part of the jack to suit the work to be held. The horizontal screw *a* is used as a side support and the vertical screw *b* acts as a jack

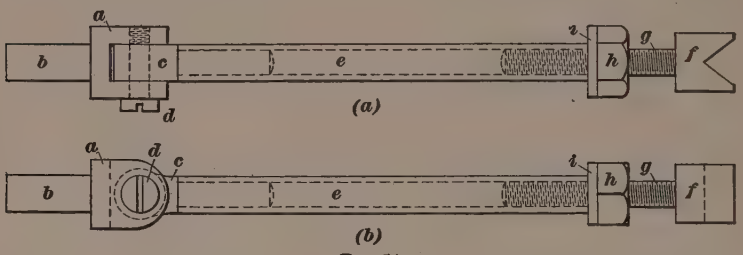

FIG. 56

under the overhanging part. These screws may be used in any of the holes, as needed.

78. Another form of planer jack is shown in Fig. 56, (*a*) being a top view and (*b*) a side view. The yoke *a* has a shank *b* of such size as to fit the holes in the planer table. An eyebolt *c* fits between the jaws of the yoke and is held by a pin *d*, forming a hinge joint. A piece of pipe *e* is screwed over the threaded end of the eyebolt, the length of the pipe being such as to suit the work to be held. At the other end is a V-shaped jaw *f* having a threaded shank *g* that passes through a nut *h* and a washer *i* and extends into the pipe. The shank *b* of the yoke is placed in a hole in the planer table and the jaw *f* is set against the work. Then the nut *h* is turned so as to force the jaw firmly against the work. This form of jack is of especial use in supporting work that extends some distance above the surface of the table.

79. Planer Centers.—Planer centers are used for holding work that must be rotated so that it may be planed on several surfaces, or so that slots may be spaced and cut on the face of the work. The set of planer centers shown in Fig. 57 (*a*) and (*b*) consist of a headstock and a tailstock, both of which have tongues on the bottom to fit the T slots of the planer table, to insure that they will be in line with each other and with the line of motion of the table. The work is held in the same way as in lathe centers. The tail of the dog fastened to the work fits in the slot in the arm *a* on the headstock spindle. On the other end of the spindle is a worm-wheel *b* that may be turned by turning the handle *c*, which drives the worm *d* meshing with

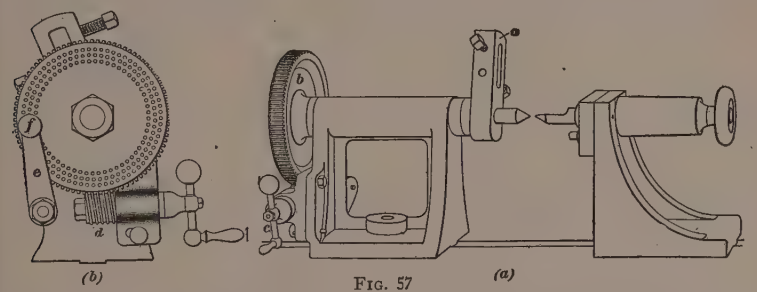

FIG. 57

the worm-wheel. The face of the worm-wheel has several circles of holes, equally spaced, forming what is called an *index plate*. An arm *e* pivoted to the headstock carries a latch pin *f* that fits the holes, and by the use of the latch pin in connection with the handle *c* for turning the worm-wheel, or index plate, a number of equal divisions on a piece of circular work may be obtained.

80. Division by Index Plate.—In order to find out whether a desired number of equal divisions of a circle can be obtained with a given index plate, the following rule may be used:

Rule.—*Divide the number of holes in the index circle by the number of equal parts into which the circle is to be divided, and if the quotient is a whole number, without any remainder, the number of divisions can be obtained. This whole number then represents the number of holes the latch pin must be advanced, not counting the hole in which it rests at the start.*

As there are several circles of holes in the index plate, the rule must be applied to the several circles in succession, until one is found that can be divided without a remainder. If no such circle can be found, some other method must be adopted.

EXAMPLE.—An index plate on a planer center has three circles of holes containing 72, 60, and 56 holes, respectively. Can a circle be divided into 14 equal parts with this index plate?

SOLUTION.—Apply the rule to the outer circle; $72 \div 14 = 5\frac{2}{14}$, which shows a whole number with a remainder; hence, the outer circle cannot be used. Trying the next circle, $60 \div 14 = 4\frac{4}{7}$, which also shows a remainder, so that the middle circle cannot be used. Trying the inner circle, $56 \div 14 = 4$, which is a whole number without a remainder; therefore, by using the circle containing 56 holes, and moving the latch pin 4 holes at a time, 14 equal divisions can be obtained. Ans.

Two circles of holes can be used if no one circle will give the number of divisions desired. With an adjustable arm at *e*, Fig. 57, one circle is used to give part of the desired turn and another circle used to complete the turn. Between the two indexing operations the latch pin *f* must be removed from one circle and located in a hole in the second circle. If the index plate is turned in the same direction during the two operations, the result is the sum of the indexings. If the plate is turned in the opposite direction during the second operation, the result is the difference between the indexings.

EXAMPLE.—Index for $\frac{10}{21}$ of a turn by using the 56- and 60-hole circles.

SOLUTION.—Separate $\frac{10}{21}$ into two indexings that can be obtained by the 56- and 60-hole circles. Thus, $\frac{10}{21} = \frac{7}{21} + \frac{3}{21}$, and $\frac{7}{21} = \frac{1}{3}$ and $\frac{3}{21} = \frac{1}{7}$. Then $\frac{1}{3} \times 60 = 20$ holes in the 60-hole circle, and $\frac{1}{7} \times 56 = 8$ holes in the 56-hole circle. Both indexings are in the same direction, because they must be added together.

EXAMPLE.—Index for $\frac{4}{21}$ of a turn by using circles with 56 and 60 holes.

SOLUTION.—As $\frac{4}{21} = \frac{7}{21} - \frac{3}{21}$, and as $\frac{7}{21} = \frac{1}{3}$ and $\frac{3}{21} = \frac{1}{7}$, the required indexing is for $\frac{1}{3}$ of a turn minus $\frac{1}{7}$ of a turn. Therefore, $\frac{1}{3}$ of $60 = 20$ holes, and $\frac{1}{7}$ of $56 = 8$ holes. The second indexing must be in the opposite direction from the first one.

PLANER PRACTICE

Serial 2214 Edition 1

TOOLS AND OPERATIONS

PLANER TOOLS

SHAPES OF TOOLS

1. Action of Planer Tool.—In planing cast iron, the metal is crushed ahead of the tool until it breaks off in chips, as illustrated in Fig. 1. The point *a* of the tool forces the metal away from the body *b* of the casting to the depth *c* of the cut. The metal is broken up ahead of the tool, as at *d*, leaving little to be removed by the point of the tool. In planing chilled iron, the chips come off in slender splinters; but with a soft metal like brass they form a shower of small particles. Soft steel produces long curls.

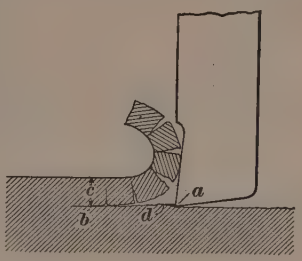

FIG. 1

2. Effect of Kind of Tool.—The shape of a planer tool to select depends on the properties of the metal to be planed, as well as on whether the cut is a roughing or a finishing cut. Planer tools are usually made from bar stock ranging in size from 1 in.$\times 1\frac{1}{2}$ in. to $1\frac{1}{4}$ in.$\times 2$ in. If only a small amount of metal is to be planed off, one roughing cut and one finishing cut

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are sufficient. When a fair finish is desired, the roughing tool is set to the required dimension of the work, and the finishing tool then merely removes the high spots that are left. When an accurate finish is desired, the roughing cut is taken so as to leave the work about .006 inch oversize. This is followed by a straightening cut that leaves .001 inch to be removed by the finishing tool.

ROUGHING TOOLS

3. Round-Nosed Roughing Tools.—A round-nosed roughing tool made entirely by grinding a length of rectangular stock is shown in Fig. 2. The rounded cutting point *a* is ground

FIG. 2

FIG. 3

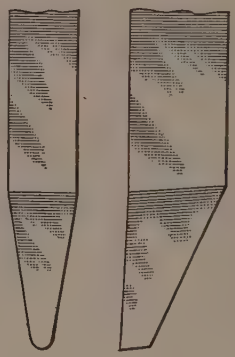
FIG. 4

slightly back of the front side of the shank, and its sides *b* and *c* are ground down equally, so that the tool has front rake but no side rake; therefore, it can be fed in either direction. The tool shown in Fig. 3 also has its cutting point *a* ground back of the front *b* of the shank, and the surface *c* has side rake as well as front rake. This tool is intended to be fed across the work with the high side of *c* leading.

4. The round-nosed tool shown in Fig. 4 is made by drawing down the stock, from the back and both sides, nearly to a point. The tool is then ground flat on the front face and on both sides as far as the cutting edges are to extend, and the point is rounded. The advantage of this tool is that it may be

started in from either side of the work, or it may be started in anywhere between two raised parts of the work and fed horizontally in either direction. It is used mainly for planing cast iron, brass, and babbitt, and to some extent on steel.

5. Tools for Side or Down Cuts.—Two forms of broad-nosed tools for side or down cuts are shown in Fig. 5 (*a*) and (*b*). The squaring-down tool with rounded corners, shown in (*a*), will take the heavier cut and will not break out the metal *a* at the bottom of the cut. The similar tool shown in

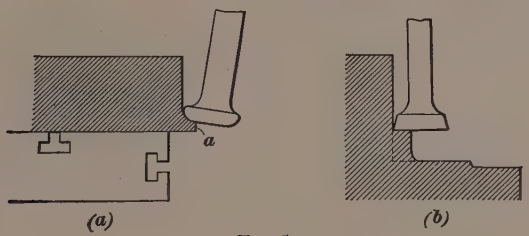

FIG. 5

(*b*) has sharp corners and is used for squaring down where a square corner must be left. The tools are shown correctly set for side cuts. When properly sharpened, the tool shown in (*a*) is sometimes used as a finishing tool, the depth of the cut being from $\frac{1}{32}$ to $\frac{1}{16}$ inch, and the feed about the same as for a roughing cut. The rounded corner leaves a smooth surface.

6. Diamond-Pointed Tool.—The diamond-pointed tool is seldom used on the planer. It makes a very good finishing tool, especially on light work, where a narrow-pointed tool and light feed must be used, and may be used for planing babbitt metal, also.

FINISHING TOOLS

7. Broad-Nosed Finishing Tools.—The forged finishing tool for cast iron has the square-nosed form shown in Fig. 6, and that for wrought iron or steel is of similar form but has a shorter cutting edge. The broad-nosed finishing tool is ground

flat on the face *a* that turns the chip, has enough front rake *b* to give a keen cutting edge, and has as little clearance *c* as it can have and yet cut freely. The cutting edge *d* is ground nearly straight for about three-fourths of its width, the portion at each end being curved slightly so that lines will not be cut on the finished surface. The round-nosed tool shown in Fig. 2

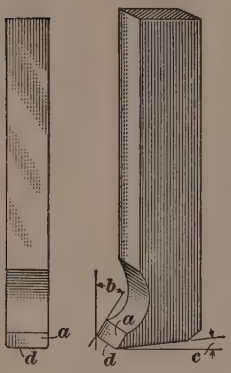

FIG. 6

FIG. 7

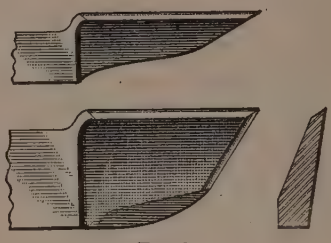
FIG. 8

is often used for finishing wrought iron and steel, in which case the curve at the point is made much flatter, or even straight for $\frac{1}{8}$ inch or so.

8. Narrow Finishing Tool.—A finishing tool like that shown in Fig. 7 is to be used at the bottom of a groove, or between two raised parts, where it must be fed in each direction. It is similar to a wide parting tool, is ground straight on its cutting edge, and is rounded at the corners with an oilstone. It is set so that it cuts equally along the whole edge.

9. Side Tools for Finishing.—In the finishing tool for side cuts, shown in Fig. 8, the cutting edge is parallel with the shank and somewhat higher than the shank when the tool is new. The cutting edge is straight and should always be kept in line with the shank; also, it should be higher at the point than at the shank end. The side face is ground with good clearance and the top face with enough rake to give a keen cutting edge. The

side face below the cutting edge must be nearly flat, except for a slight curving for a short distance back from the point. The curve and the side face should be ground and tried repeatedly until the tool, after being oilstoned, cuts a smooth surface. It is resharpened by grinding the top face only, and then oilstoning it, thus saving the time and expense of grinding the working face. All finishing tools should be oilstoned before being used.

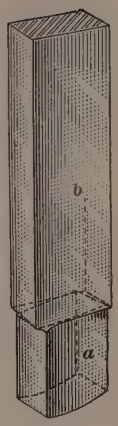

FIG. 9

10. Finishing Tool for Steel.—The special finishing tool shown in Fig. 9, intended for producing a very smooth surface on wrought iron or steel, is made with an end about $\frac{1}{2}$ inch wide, which is twisted until the side *a* makes an angle of from 15° to 25° with the side *b* of the shank. It is given about 7° of clearance. The curved cutting edge and the twist give a shearing cut that produces a very smooth surface, but the tool is too slow for general work.

11. Special Forms of Finishing Tools.—Broad-nosed finishing tools, if forged from solid stock, are expensive. For this reason various forms of special tools, in which the cutting edges are formed on small pieces of steel bolted or clamped to a holder, are often used. Fig. 10 shows three tools of this class.

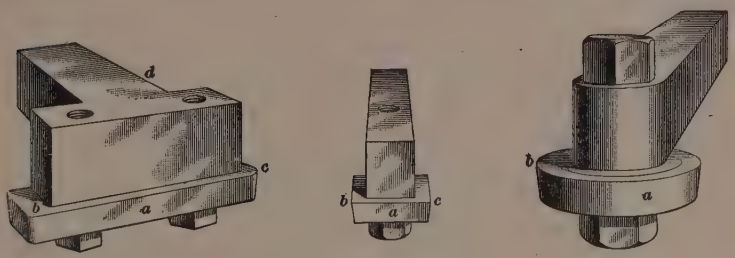

FIG. 10

The one shown in (*a*) is intended for finishing very broad surfaces. The steel tool *a* has a cutting edge *b c* and is clamped to the shank *d* by two capscrews. The tool shown in (*b*) is intended for finishing a narrower flat surface, having a square

corner. The steel tool *a* is made square, with four cutting edges as *b c*, any one of which can be brought into the cutting position. The tool shown in (*c*) is intended for finishing a fillet of large radius. The cutter *a* is circular in form, the cutting being done along the edge *b c*. The cutter can be rotated on the clamping bolt and clamped in any desired position, so that all parts of the edge can be used before resharpening. All these special tools are underhung; that is, the steel tool proper is clamped to the back side of the shank. Cutters or blades having irregular outlines may also be used on shanks similar to those shown.

GRINDING PLANER TOOLS

12. Forms of planer tools ground from the bar, without any forging, are shown in Fig. 11. In connection with each tool is a sketch showing the direction in which the tool *a* is fed into the work *b*. The tools shown in (*a*), (*b*), (*c*), (*d*), and (*e*) are round-nosed roughing tools made of high-speed steel brazed to machine-steel shanks. The tool in (*a*) has no side rake and may be used for shallow cuts and fed from either left or right. The angles to which the tools in (*b*) and (*c*) are ground apply to operations on cast iron, while the forms in (*d*) and (*e*) are used on steel. Square-nosed roughing and finishing tools for cast iron are shown in (*f*) and (*g*), respectively. The roughing tool is made of high-speed steel and the finishing tool of high-carbon steel. A very useful finishing tool for cast iron and steel is the forged gooseneck tool, shown in (*h*). It is made of high-carbon steel and is used for taking shallow cuts with a feed almost equal to the width of the tool. After being ground, the cutting edge of the tool is finished by hand with an oilstone, to remove burrs and produce a keen, straight edge. Care should be taken to set this edge exactly parallel to the surface of the work; otherwise its corners will dig in.

13. High-speed steel roughing and finishing tools for operating on dovetailed surfaces in cast iron are shown in Fig. 11 (*i*) to (*p*). The roughing tools in (*i*) and (*j*) have rounded corners so as to be able to take a deep cut without breaking.

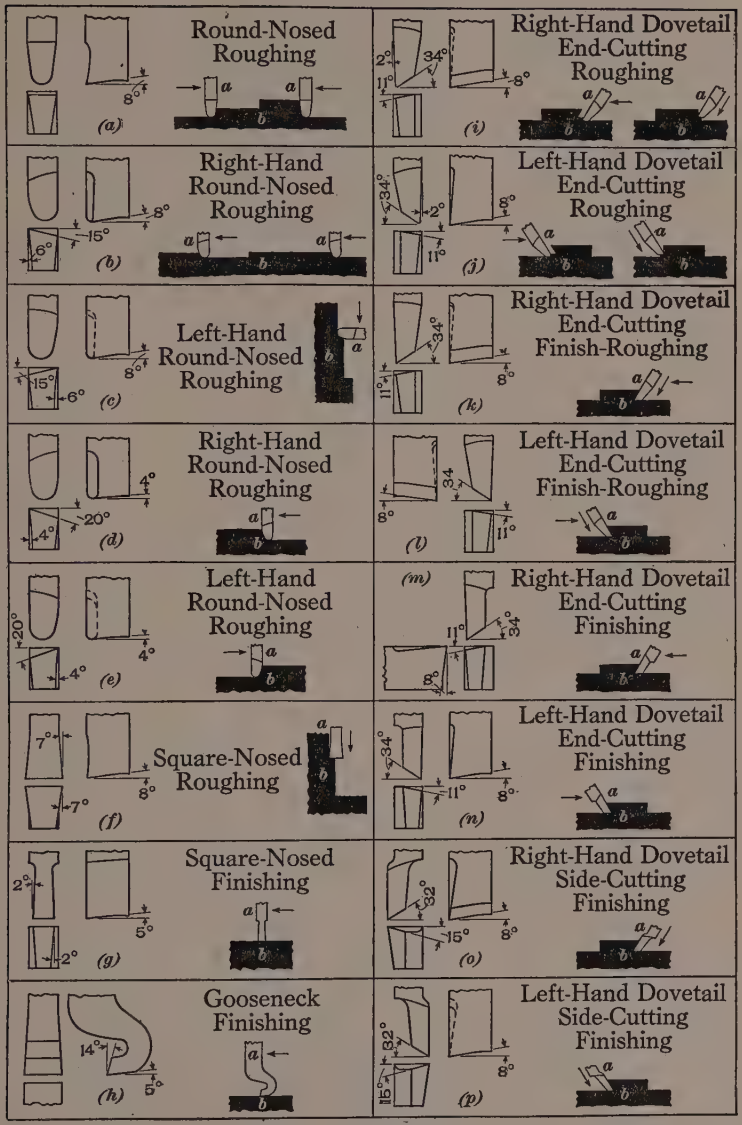
Round-Nosed Roughing
8°
(a)
Right-Hand Round-Nosed Roughing
8°
15°
6°
(b)
Left-Hand Round-Nosed Roughing
8°
15°
6°
(c)
Right-Hand Round-Nosed Roughing
4°
20°
4°
(d)
Left-Hand Round-Nosed Roughing
20°
4°
4°
(e)
Square-Nosed Roughing
7°
8°
7°
(f)
Square-Nosed Finishing
2°
5°
2°
(g)
Gooseneck Finishing
14°
5°
(h)
Right-Hand Dovetail End-Cutting Roughing
2°
34°
11°
8°
(i)
Left-Hand Dovetail End-Cutting Roughing
34°
2°
8°
11°
(j)
Right-Hand Dovetail End-Cutting Finish-Roughing
34°
11°
8°
(k)
Left-Hand Dovetail End-Cutting Finish-Roughing
34
8°
11°
(l)
(m)
Right-Hand Dovetail End-Cutting Finishing
11°
34°
8°
Left-Hand Dovetail End-Cutting Finishing
34°
11°
8°
(n)
Right-Hand Dovetail Side-Cutting Finishing
32°
15°
8°
(o)
Left-Hand Dovetail Side-Cutting Finishing
32°
15°
8°
(p)

FIG. 11

They are to be followed by the tools shown in (*k*) and (*l*) for cleaning up corners left by the rounded tools. The tools shown in (*i*) to (*m*) have the cutting edge at the end and aside from feeding from right to left, or left to right, may also be fed downwards. In (*m*) and (*n*) are shown right-hand and left-hand finishing tools of high-carbon steel, having the cutting edge at the end of the tool. The forms shown in (*o*) and (*p*) are side-cutting finishing tools made of high-carbon steel. They may be fed downwards with a coarse feed, taking a very light cut.

SETTING PLANER TOOLS

14. Setting Roughing Tools.—The cross-rail of the planer should be set as close to the work as practicable, and securely clamped. The roughing tool should be set with its cutting edge projecting as little as possible, and should be rigidly clamped before a cut is taken. The tool should be adjusted for depth of cut by the feed-screw of the tool slide. Care should be taken to have as little lost motion as possible in the various parts of the planer. The head and the tool slide should be free to move, but the screws and gibs should be tightened to take up any lost motion.

15. Setting Finishing Tools.—Great care must be taken in setting finishing tools, if the best results are to be obtained. The broad-nosed finishing tool should be set so that the straight part of the cutting edge rests nearly flat on the surface of the work. The end of the cutting edge on the leading side of the tool, which is the side facing in the direction of feed of the tool, should be slightly lower than the end that follows. The exact amount cannot be measured easily, as it is only a fraction of the thickness of tissue paper. The leading end does most of the cutting, and the remainder is relieved of the work, with the result that chattering is prevented and a smooth surface is obtained. Finishing tools are first set by eye, as nearly as possible, and are lightly clamped. The planer is next started and a light scraping cut is taken at some point of the surface to be finished. Adjustments of the setting are then made as required,

after which the tool is clamped firmly and set to the desired feed.

16. Use of Parallel in Setting Tool.—If a cut has already been taken over the work and it is required to take a finishing cut, one way of adjusting the tool is to bring it up to the work until it just grips a parallel about $\frac{1}{2}$ inch thick held against the work. The table is then run along until the tool is opposite the end of the cut, and the parallel is gripped as before. The work must then be adjusted on the table until the parallel is held with the same pressure at both ends of the cut.

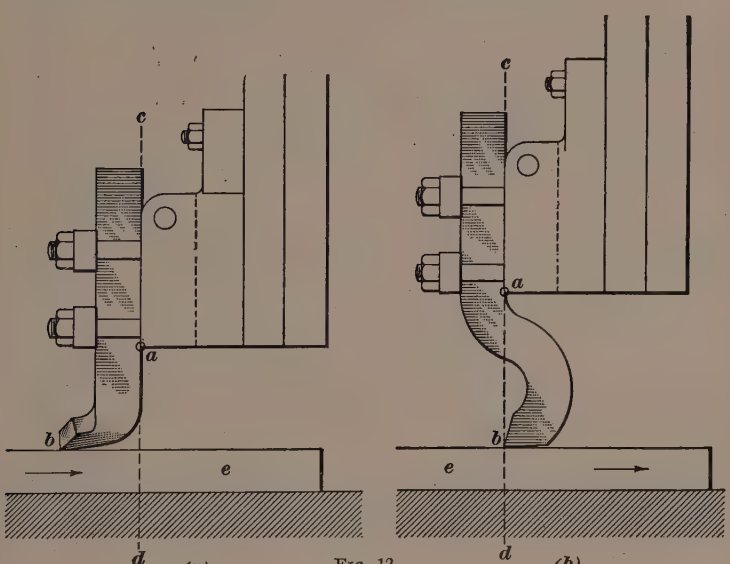

FIG. 12

17. Spring of Planer Tools.—The pressure of the cut tends to bend or spring the tool backwards about the lowest point against which its shank is supported. For example, in Fig. 12 (*a*) and (*b*), the pressure of the cut acting against the point of the tool will tend to spring the tool backwards and cause it to swing around the point *a*. If the cutting edge *b* of the tool is ahead of a vertical line *c d* drawn through the point *a*, as in (*a*), then the bending backwards of the tool will cause the edge *b* to swing down and cut deeper into the work *e*.

But if the tool is underhung so that its edge *b* is on the vertical line *c d* through *a*, as in (*b*), or if it is behind this line, then any bending of the tool backwards will cause the edge *b* to swing upwards and not cut too deep. This form of tool may prevent chattering.

TOOL HOLDERS

18. Requirements of Good Tool Holder.—Tool holders of various forms are used to reduce the cost of steel for cutting tools. The tool holder consists of a shank of machine steel having at the end a holding device in which is fixed a small cutting tool of carbon steel or of high-speed steel. This small tool requires much less steel and is cheaper than a tool in which both the shank and the cutting end are of tool steel. A tool holder intended to be used on a planer should have a very stiff shank and should not only hold the tool firmly, but should support it close to the cutting edge.

Fig. 13

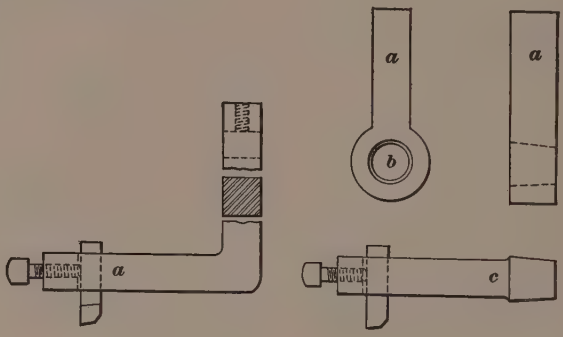

Fig. 14

19. Double-Ended Tool Holder.—The form of tool holder shown in Fig. 13 is double-ended, so that a tool may be fitted in either end to suit the work to be done. In the illustration, a finishing tool *a* is held in the gooseneck end of the holder *b* by the setscrew *c*, a shoulder being formed at *d* to give a firm support for the tool. The straight end *e* is used when the tool must work close to a shoulder or in a pocket, and the gooseneck end in other cases.

20. Extension Tool Holder.—Extension tool holders are used on work that cannot pass the planer head, as in the cutting of keyways in gears and pulleys. The form shown in Fig. 14 (*a*) consists of a piece of square steel bent to a right angle, the arms being of unequal lengths. Each end has a slot for the tool and a tapped hole for a setscrew to clamp the tool. The tool is shown clamped at *a*, and the other arm is clamped in the regular tool head of the planer, so that the tool may be raised on the return stroke. The form shown in (*b*) consists of a shank *a* with a tapered hole *b* at the lower end, into which is driven the cutter bar *c* that holds the tool.

21. Revolving Tool Holder.—A holder that permits the tool to be held in any position in a vertical plane is shown in Fig. 15. The tool is held in the block, or clapper *a*, by two clamp screws, and the block is hinged in the box, or turret *b*, on the pin *c*. The box *b* is held on the shank *d* by a heavy bolt having a washer *e* and a nut *f*. A thumbnut *g* on the side of the shank operates a locking pin that registers with any notch in the circumference of the turret bolt. A flat spring *h* attached to the turret, and a pin *i* set in the block *a*, permit the tool to lift on the return stroke.

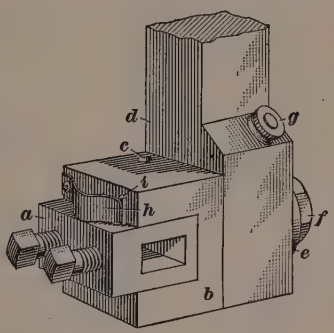

FIG. 15

22. Use of Gang Tool.—It has been found that it takes less power to cut several thin chips at one time by the use of a gang tool than to cut a single chip having a thickness equal to the combined thickness of the thin ones; also, the surface left after removing the single heavy chip is rougher than that left from the thin chips, and the edges of the work are more broken. However, as the gang tool may be troublesome on account of its complicated form, the usual practice is to use the single tool and speed up the planer to increase the number of cuts.

CUTTING SPEEDS

23. Conditions Affecting Cutting Speed.—The cutting speed of a planer must not be so high as to cause the tool to become dull very rapidly, and it should vary according to the metal being cut, the hardness of the metal, and the kind of cut being taken. Generally, the speed for a finishing cut is slower than for a roughing cut. The cutting speeds on various metals are about as follows: Cast iron, 40 to 50 feet per minute; steel castings and machinery steel, 20 to 35 feet per minute; wrought iron, 30 to 45 feet per minute; brass and bronze, 50 to 60 feet per minute; tool steel, 20 to 30 feet per minute. The use of high-speed steel tools has enabled the cutting speed to be increased greatly, but in most cases a speed of 55 feet per minute is about the greatest that can be used advantageously.

24. Finding Speed of Planer Table.—The speed of the table on the cutting stroke may be found by the aid of a watch. The dogs are set so that the table makes its full stroke, and the length of this stroke, in feet, is measured. By aid of the watch, the time required for the table to move this distance is found, in seconds. The speed of the table is then found by the following rule:

Rule.—*To find the speed of the table, in feet per minute, divide the length of stroke of the table, in feet, by the number of seconds required to make the stroke, and multiply the quotient by 60.*

The speed of the table on the return stroke may be found by the same rule, except that the time used must be the number of seconds required to make the return stroke. If a cut meter is at hand, it may be applied directly to the top of the moving table and the speed on either stroke may thus be found at once.

EXAMPLE.—A planer table has a full stroke of 16 feet and requires 24 seconds to make the stroke. What is its speed?

SOLUTION.—Apply the rule, and the table speed is

$$\frac{16}{24}\times 60 = 40 \text{ ft. per min. Ans.}$$

25. Effective Cutting Speed.—To find the effective cutting speed, or the actual length of cut made in one minute, it is necessary to take into account the time required for both the forward and the return stroke of the table, as the cut is taken on the forward stroke and the tool is idle on the return stroke. If the cutting speed, or the forward speed of the table, is 30 feet per minute, and the return stroke is made at the same speed, then the effective cutting speed is $30 \div 2 = 15$ feet per minute. If the forward stroke is made at the rate of 30 feet per minute and the return stroke at the rate of 60 feet per minute (which is equivalent to 30 feet in $\frac{1}{2}$ minute), the effective cutting speed is $30 \div (1 + \frac{1}{2}) = 20$ feet per minute. Return speeds of from 75 to 100 feet per minute are common; beyond the latter speed the sudden reversing imposes too great a strain on the machine and shafting.

26. It is safer and more effective to increase the cutting speed a relatively small amount without increasing the return

TABLE I
EFFECTIVE CUTTING SPEEDS

Forward Speed Feet per Minute	Return Speed, in Feet per Minute							
	50	60	70	80	90	100	120	150
	Effective Cutting Speed, in Feet per Minute							
20	14.3	15.0	15.5	16.0	16.4	16.6	17.1	17.6
25	16.6	17.6	18.4	19.0	19.6	20.0	20.7	21.4
30	18.75	20.0	21.0	21.8	22.5	23.1	24.0	25.0
35	20.6	22.0	23.3	24.3	25.2	25.9	27.1	28.4
40	22.2	24.0	25.5	26.6	27.7	28.6	30.0	31.6
45	23.7	25.7	27.4	28.8	30.0	31.0	31.1	34.6
50	25.0	27.3	29.2	30.8	32.1	33.3	35.3	37.5

speed than to attempt to increase the return speed a large amount without increasing the cutting speed. This may be shown by the data in Table I, which gives the effective cutting speeds, in feet per minute, for given cutting and return speeds.

Suppose that the cutting speed is 30 feet per minute and the return speed 50 feet per minute. From Table I, the effective cutting speed is found to be 18.75 feet per minute. If the cutting speed is not changed, but the return speed is increased to 90 feet per minute, the effective cutting speed becomes 22.5 feet per minute. On the other hand, if the return speed is left unchanged at 50 feet per minute and the cutting speed increased from 30 to 45 feet per minute, the effective speed becomes 23.7 feet per minute. By increasing the return speed a reasonable amount, as, for instance, to 70 feet per minute, an effective cutting speed of 27.4 feet per minute may be obtained.

PLANER OPERATIONS

SETTING PLANER WORK

27. Use of Size Blocks.—Size blocks are pieces of tool steel hardened and ground to size, and marked with their thicknesses. They are usually made in sets increasing by $\frac{1}{16}$ inch. If a surface is to be planed at a certain height above another surface, as in Fig. 16, a size block *a* of the proper thickness is laid on the lower surface *b* and the tool *c* is run down until it just allows the block to slide beneath it. The tool is then set to plane the required upper surface. The size block is not so accurate as the depth gauge, but may be used more quickly.

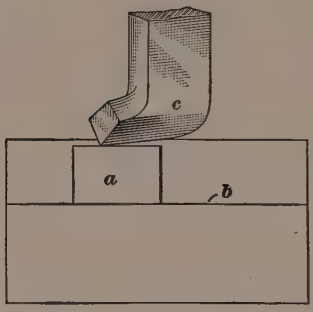

FIG. 16

28. Use of Surface Gauge.—The use of the surface gauge in setting work parallel to the table is illustrated in Fig. 17 (*a*). The line *a* is marked on the face of the work to indicate the surface that is to be set parallel to the table. The pointer *b* of the gauge is then set to one end of the line, the base *c* resting fairly on the table. The surface gauge is now moved along the table

to the other end of the work, and it is noted whether the pointer *b* fits into the other end of the line. If it does not, the work is shifted a little and the test is repeated until the pointer touches the line fairly when at either end of the work. The line is then parallel with the table. The gauge is used as shown in (*b*)

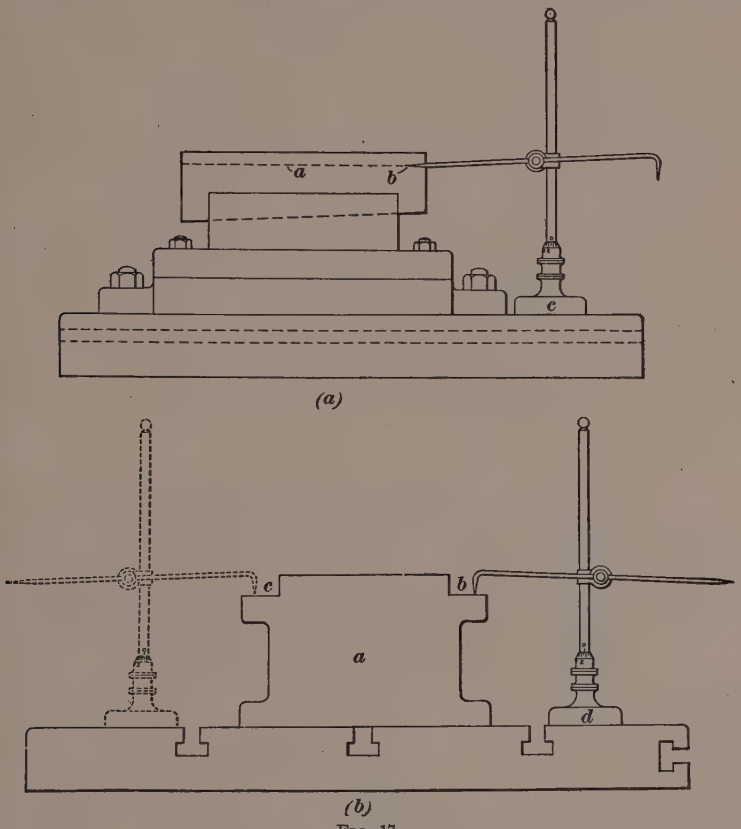

FIG. 17

when the work *a* has two surfaces *b* and *c* that are to be set at the same height above the table. The curved pointer is set to touch the surface *b* and then the gauge is moved over to the dotted position. If the pointer does not touch the surface *c*, the work is blocked up and the testing is repeated until the pointer touches both surfaces when shifted from side to side of the work.

29. Warping of Planed Work.—The uneven cooling of castings and forgings, and the hammering that they may receive, set up forces, called *internal stresses,* in them. These stresses are usually strongest at the surface of the work, and when one side is planed the work is likely to warp, especially if it is long and thin. Hence, to produce the truest work all the roughing cuts should be taken before any of the finishing cuts. This will relieve most of the internal stresses and the work will assume its permanent shape. The light finishing cuts will true the work and will not cause enough additional warping to be noticeable.

30. Suppose that a straight casting is clamped carefully so that when it is laid on the table it has a fair bearing, and that a cut is taken over the top so that it is straight. On

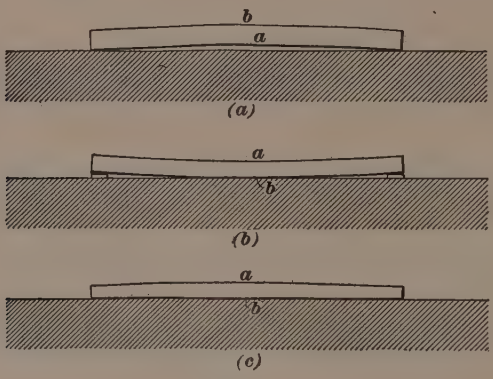

FIG. 18

removing the clamps, the piece may spring up in the center, as shown somewhat exaggerated in Fig. 18 (*a*). Before the piece is planed, the stresses at the two sides *a* and *b* are about equal; consequently, the piece remains straight. On taking a cut over one side, as *b,* some of the stresses are relieved, and the stresses at the side *a* bend the work upwards at the center, as shown. If the piece is turned over, as shown in (*b*), and carefully clamped with pieces under the ends, so that it will not be sprung in clamping, and if a cut is now taken over the top surface *a* as deep as the cut that was taken over the lower

surface *b*, it will be found upon releasing the clamps that the work will again change its form, this time springing back to about its normal shape. The lower face *b* will again be nearly straight and the upper face *a* curved, as shown in (*c*).

31. Spring of Work in Clamping.—Another cause of untrue work is improper clamping. A very slight pressure of

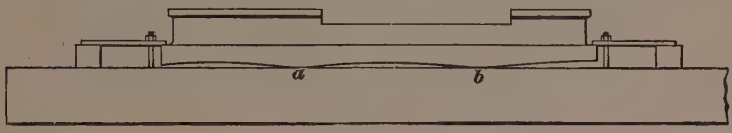

FIG. 19

misplaced clamps may seriously spring the work out of shape. A casting or a forging is never true, and when it is first put on the table it rarely touches at more than three points. When correctly set, the work does not actually touch the table, but rests on packing or blocking at the various points of support. The piece shown in Fig. 19 illustrates springing due to incorrect clamping. The bottom of the piece has high spots *a* and *b* at some distance from the ends, where the clamps are set. The pressure of the clamps will therefore spring the center of the work upwards, and when the planing is done and the clamps are removed, the piece will spring back and be low at the middle.

32. Correct Setting of Work.—There should be a parallel block under the work at each point over which a clamp is set, as shown in Fig. 20, to prevent springing. When a piece

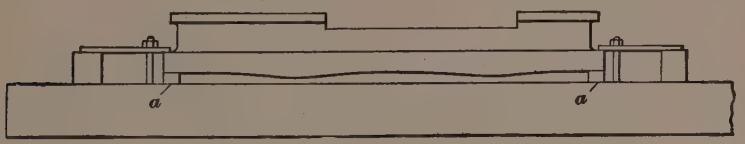

FIG. 20

is supported by a block under each of the four corners, it will usually be found to rock more or less on diagonally opposite corners. To prevent this rocking, strips of cardboard are added on top of the loose blocks. If there is still a tendency to rock,

strips of paper of the same thickness may be added at the loose corners until the work rests solidly. The top surface is then tested with a surface gauge and if one end is low, extra blocking is used to bring it to the correct level. The clamps are finally applied, and are placed as nearly over the blocks as possible. If the work is not too large or too much out of true, pieces of cardboard may be used instead of parallel blocks. Card or paper blocking has the advantage of being easily obtained and cut into strips of suitable size. When placed under the work, they reduce vibration and tend to prevent slipping. They also show whether the work is solidly bedded. If they are held tightly, the work is correctly set; and if they are loose, it is not properly set.

33. Papering When Resetting.—After a surface has been planed and the piece is turned over to be reset on the table, it may be found to be sprung slightly, so that it will rock on opposite corners. A strip of tissue paper should be placed under

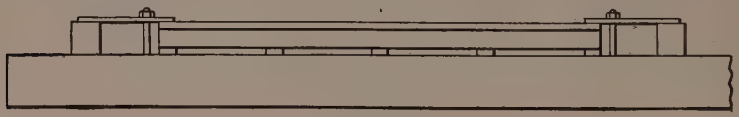

FIG. 21

each corner and pulled gently. If all are held with the same pressure, the work is bedded properly. If two opposite strips are loose, and the other two are tight, strips of the same thickness should be added under the loose corners until all are held equally. It is possible to get a perfect bearing in this way, if enough care is taken.

34. Sag of Long Work.—A long piece of work supported only at its ends will sag at the middle, due to its own weight and to the pressure of the tool in cutting; consequently, when it is turned over it will be high in the middle. A piece of this kind should be supported at the corners in the usual way, but should have other supports at regular distances, as shown in Fig. 21. A slip of heavy paper should be placed on each support and pulled gently at the same time that the work is rapped

lightly with a hammer directly over the support. In this way looseness of some slips may be found. It is then necessary to add slips of paper at the loose points until all are held firmly while the work is rapped with the hammer, after which the clamps are put on.

35. Straightening Long, Thin Work.—It sometimes happens, when planing long, thin work, that the piece springs after the first cut and that it will not true up when reset by the blocking method. A piece of this kind may possibly be saved by being straightened before it is reset for the cut on the other side. A short cast strip may be straightened by holding it at the ends, with the hollow surface downwards, and letting one end fall on a solid casting. It is then tested on the table, and if

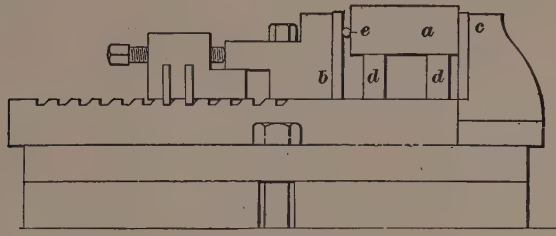

FIG. 22

it is still untrue, the operation is repeated until the work is fairly straight. It is then reset and clamped and the other side is planed. This method of straightening may be used for machine parts that are afterwards held firmly in position, but should not be used for straightedges and similar work.

36. Chucking Thin or Narrow Work.—If the piece of work to be planed is thinner than the depth of the chuck jaws, it must be blocked up by having parallels placed under it. A case of this kind is shown in Fig. 22, in which the piece of work *a* is held above the upper edges of the jaws *b* and *c* by the pair of parallels *d*. A strip of paper should be placed at each end of each parallel, under the piece of work. When all the strips are held tightly it is known that the work is resting solidly on the parallels. A piece of round stock *e* is placed between the jaw *b* and the work *a*. This transmits the pressure of the

jaw *b* in such a way that the work is forced squarely against the fixed jaw *c*, while it rests on the parallels.

37. Holding Very Thin Work.—Very thin and flat work that is to be planed all over its top and that cannot be held by toe clamps, can be held on the table by imbedding it in plaster of Paris, or by placing a mixture of melted rosin and beeswax along its edges. When rosin is used, it is necessary that the edges of the work, as well as the table along the edges of the work, be carefully cleaned so that the rosin will stick to them. Shellac, sealing wax, or pitch may be used in place of rosin, but rosin is easier to obtain and is cheaper.

38. Setting Round Work.—Round work, such as a shaft in which a long keyway is to be cut, may be set and clamped to the table as shown in Fig. 23. The shaft *a* is laid in one of the T slots *b* of the table, and bent clamps *c* are applied at opposite points along its sides. Each pair of clamps should be tightened equally, so as not to spring the shaft sidewise. To prevent the clamps from slipping, stop-pins *d* are used.

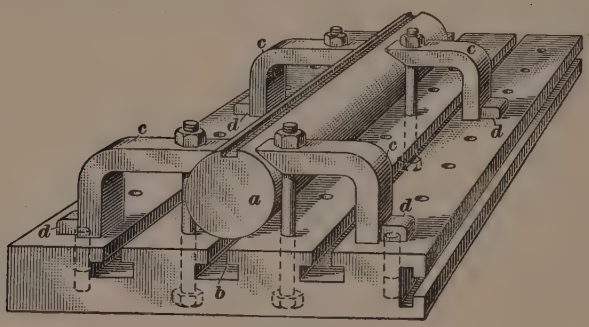

FIG. 23

39. Use of Screw Plugs.—The use of screw plugs is confined mainly to work of medium or light weight and is illustrated in Fig. 24, which shows the method of holding a casting *a* that is to be planed over the top. The casting is placed lengthwise on the table *b* and a screw plug *c* is inserted in a hole near each corner of the work, along the side. A piece of heavy paper or sheet metal *d* is placed under each corner of the work,

and if the casting is not true, it will rock. To prevent this, more pieces should be put under the opposite loose corners until the work rests firmly, without rocking. The setscrews in the plugs *c* are then tightened against the sides of the work. If the casting is now found to be raised, so that the card packing is loose at the corners, the plugs *c* should be driven down until the

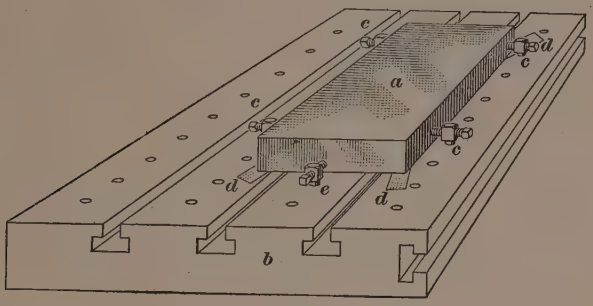

FIG. 24

card strips are held tightly all around. One or more plugs *e* at the end prevent endwise motion of the work.

40. Lining Work by Screw Plugs.—Work held by screw plugs may easily be lined. A tool is clamped in the tool holder and is set so that its point is directly over one edge of the work near the end. The planer table is then run back and forth under the tool, and if the work is not in line, the edge will not be beneath the tool point at the opposite end of the stroke. To bring it into line, the screw plug at one side is loosened and the opposite one is tightened, and this is repeated until the edge follows the point of the tool through the entire stroke. If the surface of the work has scribed on it a line that is to be set parallel to the direction of motion of the table, a sharp-pointed tool is used, and the screw plugs are adjusted as already described, until the tool point follows the line exactly.

41. A piece of work held by screw plugs may have a finished side surface that must be set parallel to the line of motion of the table. The screw plugs are adjusted until a steel rule inserted between the tool point and the surface is held with the same pressure at each end of the piece of work. The tool

point is then run very close to the surface and the screw plugs are further adjusted until the tool touches the work with a slight but uniform contact throughout the whole return stroke. This contact may be felt by holding the hand against the tool clamp. A still more accurate way is to make the test during the cutting stroke; but the tool must only scrape the work lightly and must not cut it.

42. Use of Paper Strips.—The use of paper strips between the work and the planer table is of advantage. The paper increases the friction between the work and the table to such an extent that often much heavier cuts can be taken without causing either the work itself, or the fixtures by which the work is held in place, to be moved by the thrust of the cut. The use of paper for this purpose is especially of advantage when the work is too thin to be clamped with great pressure to prevent it from slipping when the cut is taken. The best way is to use the paper strips between the work and the table and between the clamps and the work. When more than one finishing cut is taken over the work, a paper strip may be placed between the tool block and the box, which may be done by raising the tool block on its hinge and inserting the paper from the top behind the block. The insertion of the paper raises the cutting edge of the tool a very small amount; after the cut is taken with the tool in this position, the paper is removed, causing the cutting edge to be lowered a slight amount and enabling it to take the final finishing cut.

43. Supporting Irregular-Shaped Work.—Some work, because of its peculiar shape, requires special supporting fixtures. For example, the two pieces *a*, Fig. 25, are parts of the frame that supports the cylinder of a vertical engine. They are carried on a fixture *b* that fits the curved castings and is bolted to the table. The flange on the casting keeps it from slipping down and setscrews *c* at the side of the fixture are used for adjusting the work. The lower end of the casting overhangs the table and is kept from slipping lengthwise, when a cut is being taken, by the use of a heavy bar bolted to the table. A setscrew *e* in the end of this bar is used to make slight adjust-

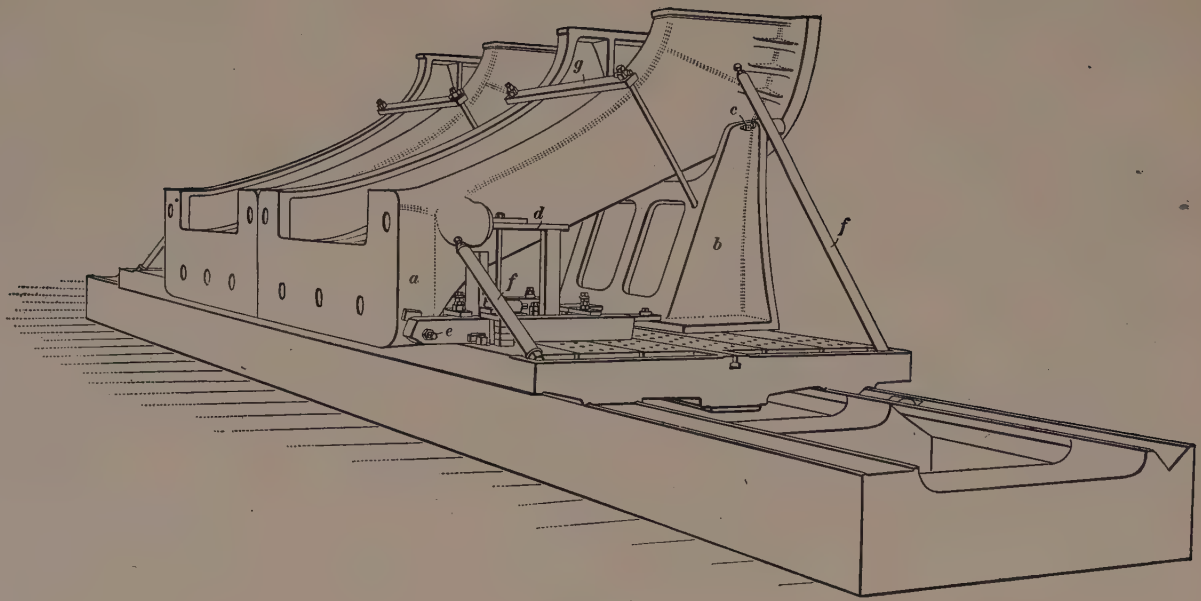

FIG. 25

ments when setting the work true. Planer jacks *f* are also used to keep the work from slipping and tipping. The clamps for holding down the work are shown at *d* and *g*. When heavy work is securely braced and rests fairly on a fixture, its weight helps to hold it down, so that very heavy clamps are not necessary. A large number of small pieces can be planed at the same time by using either individual or combination fixtures bolted to the table. The fixtures are made exactly alike, so that the work may be clamped quickly.

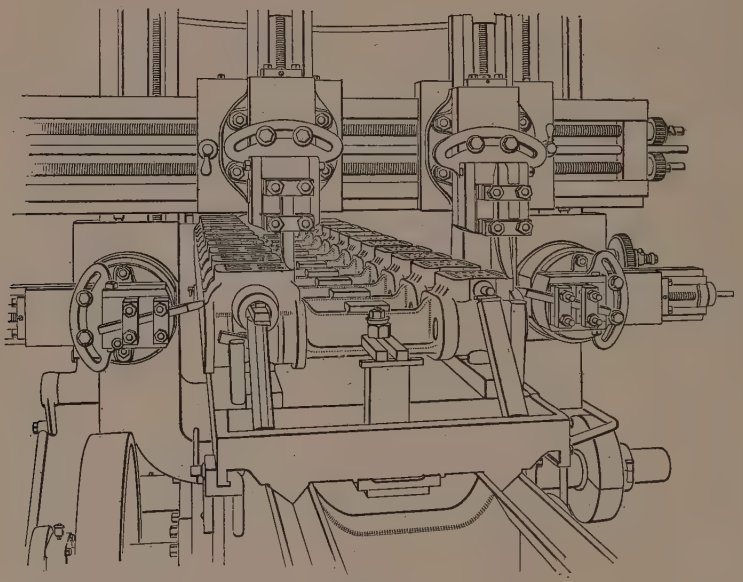

FIG. 26

44. String Planing or Gang Planing.—If a number of similar pieces are to be planed in the same way, time may be saved by arranging them in a string, or gang, on the planer table, as shown in Fig. 26, and taking continuous cuts over all. In the case illustrated, each of the eleven pump castings is carefully set and clamped in place, with as little space as possible between adjoining castings. The four heads of the planer are in use at one time, thereby planing the top surfaces and the ends of the castings in one setting.

45. Setting Block in Chuck.—Suppose that a rough cast-iron block is to be planed accurately square in a chuck. The truest surface is found by rocking the block on the planer table and this surface is placed against the fixed jaw *a* of the chuck, Fig. 27 (*a*). A piece of card *b* is put under each end of the block, to prevent rocking, and a piece of round iron *c* is placed between the block and the movable jaw *d*. The movable jaw is

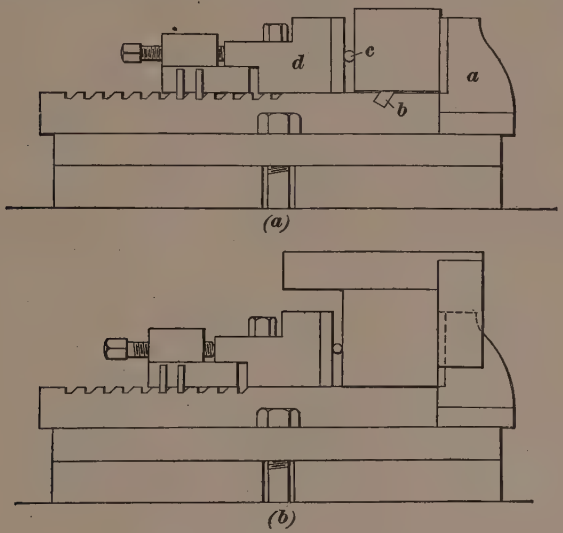

FIG. 27

then screwed up so as to grip the block, and the round piece *c* should be raised or lowered so that the card *b* is held tightly when the jaw *d* is tightened. A hammer should not be used to drive the work down in the chuck, as it is apt to spring the piece and injure the chuck.

46. Planing of Block.—When the block is correctly set in the chuck, a roughing cut is taken across the top. This planed surface is then placed against the fixed jaw of the chuck and the work is reset and planed. It is then turned over, and the bottom is planed, after which the remaining surfaces are roughed out. When roughing cuts have been taken all over the block, it is removed and both the work and the chuck are

brushed clean. It is then reset, with strips of paper underneath it instead of pieces of card, and finishing cuts are taken over the surfaces in succession. After the second surface has been finished, the try square is applied, as in Fig. 27 (*b*), the beam being set against the first finished surface and the blade against the surface to be tested. If no light can be seen between the blade and the horizontal surface, the two surfaces are square and the other faces may be finished.

CUTS AND FEEDS

47. Setting Cross-Rail and Tool for Flat Surfacing.—The cross-rail should be set as close as possible to the work. If it is too high, it must be adjusted before a cut is taken. To do so, the feed is thrown out and the clamps at the back of the rail are loosened. The rail is then lowered slightly beyond the required working position, and then raised from $\frac{1}{4}$ to $\frac{1}{2}$ inch in order to take up all lost motion in the gears and the screws, after which the rail clamps are tightened.

The tool for taking a cut over a flat surface should be firmly clamped to the tool block, with the cutting edge projecting as little as possible below the block, to lessen springing. The head is then moved to bring the tool close to the work and the down-feed screw is adjusted to give the tool the desired depth of cut. After the tool has been moved up to the work and the cut is begun, the feed is thrown in.

48. Order of Cuts in Planing.—Planing is done to the best advantage by taking the cuts in the following order: If the work has several surfaces to be planed, all roughing cuts should be taken before any finishing cuts; otherwise, warping will result and truest work cannot be produced. The main lengthwise cuts over the top and bottom of the work should be taken, and followed by such side cuts as can be made with vertical feeds. If there are some side cuts that cannot be made conveniently with the work set for planing the top or the bottom, the work is turned on edge and is fastened to an angle plate, after which the remaining side cuts are taken. Finally,

the piece is swung around and set squarely across the table, so that the ends may be planed square with the top and the sides.

49. Depth of Cut and Feed.—For a roughing cut the depth of cut and the feed are made as great as the tool will stand and the planer will carry, but they must not be so great as to spring the work or break out the metal ahead of the tool point. The power required to bend a chip depends on the thickness, rather than on the width of the chip; also, if the thickness of the chip can be reduced without reducing the feed, a greater surface can be planed in a given time. For example, Fig. 28 (*a*) shows the

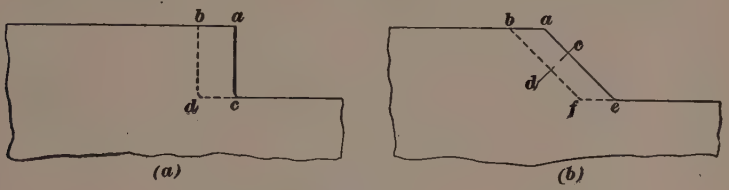

FIG. 28

shape *a b d c* of a chip cut by a tool that is set vertical, the feed being equal to *a b*. If the same tool had its cutting edge at an angle of 45° and were given the same feed *a b*, it would cut a chip of the shape *a b f e*, as in (*b*). This chip has the same area as that in (*a*), so the same amount of metal would be removed in each case; but the thickness of the slanting chip is only *c d*, while that of the straight chip is *a b*, which is greater than *c d*. The chip in (*b*) will therefore take less power than that in (*a*), and the work can be done more easily and quickly.

50. Finishing Cuts.—The finishing cut on a cast-iron piece should be made with a very small depth, and with a very broad feed all in one direction, if possible, so that the tool marks will be regular. The planer should not be stopped while the surface is being planed, or there will be a line or a streak where the stop occurred. If the tool must be fed in both directions, it should be set as squarely as possible to the work and the feed in both directions should be the same. No lubricant should be put on cast iron while it is being finished, and the hands should not be laid on a cast-iron surface that is being finished; for the

tool will ride over the work instead of cutting, at the spots where the surface is oily or greasy, and high spots on the finished work will result. The feeds for finishing metals other than cast iron vary according to the metal. The cuts are usually somewhat deeper than for cast iron, and the feeds are somewhat narrower.

51. Time of Feed.—The feed may take place at either end of the stroke, but it is better in most cases to have the feed take place as the return stroke commences, as the power required to operate the feed can be spared better at that time; also, the heel of the tool returns over the unplaned surface and raises the point slightly from the work. It sometimes happens, however, that the tool is heavy and the work has openings in it, or a number of pieces are openly spaced along the table so that the

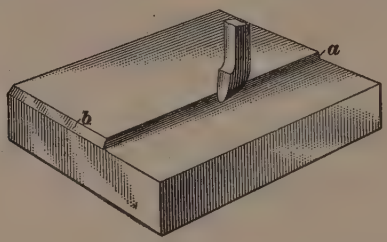

FIG. 29

tool point strikes the raised front of each opening during the back stroke. In such cases it is better to have the feed take place after the planer reverses and before the cutting stroke commences. If the tool is fed just before the cut, it is best to make the stroke longer, so that the feed will be completed before the cut commences. If this is not done, and the tool feeds as it begins to cut, it will have too much side thrust, which is liable to swing the tool to one side and also to cause chattering The feed friction is liable to slip, which reduces the size of chip taken. It is thus seen that judgment should be used in determining at which end to feed, so that the best results will be obtained.

52. Beveling Edges of Work.—It is well to bevel the edge *a*, Fig. 29, at which the cut starts, as the tool will then start

cutting without shock or jar. The hard corners and scale are removed by beveling, and the tool remains sharp longer. When taking a roughing cut, the tool will break out the metal at the edge of the work just as the cut is being finished, and if the broken portion extends below the level of the surface being planed, a ragged and unsightly edge will be produced. To prevent this, the metal should be beveled off with a cold chisel to an angle of about 45°, as shown at *b*, to a depth equal to the depth of the cut.

53. When a finishing cut is taken, the edges should be beveled by filing rather than by chipping. The file most commonly used in planer work is a 10- or 12-inch smooth file. It may be provided with a handle and used as in ordinary bench work, but for most classes of work the handle is removed and from $\frac{1}{2}$ to $\frac{3}{4}$ inch of the sharp end of the tang is cut off, leaving the end blunt, which prevents injury to the workman or the work. The advantage of having no handle on the file is that it may be laid flat to remove burrs or high spots that are often found on the table; also, the blunt tang finds many uses in setting and resetting work and in loosening chips packed in T slots and plug holes.

54. Setting Tools for Side Cuts.—A side cut should not be so heavy as a cut on the top surface, because the tool extends farther from the tool block and therefore has more spring. If the work is so shaped that the side cut runs out at the bottom, as in Fig. 30, a round-cornered tool is used. The down-feed slide is run to the lowest point at which it will clear the work. The tool is then clamped so that its edge will reach slightly below the lowest point of the cut, with the shank inclined away from the face to be planed. It is then run to the top and adjusted to the required position, the saddle is clamped, and the down-feed is started. The square-cornered tool is set in the same way as the round-cornered tool, except that the top of the shank is inclined more toward the work. This is done so that, when the tool reaches the corner at the bottom, the whole cutting edge will not cut at once and cause chattering. When the cut is nearly at the bottom, the tool should be moved away from

the side face and set so that it scrapes the horizontal surface already planed. It should then be fed crosswise by hand so as to form a square corner.

55. Testing Vertical Setting of Head.—When a down cut is to be made at right angles to the table, the swivel plate and the down-feed slide of the head should be tested to see that they

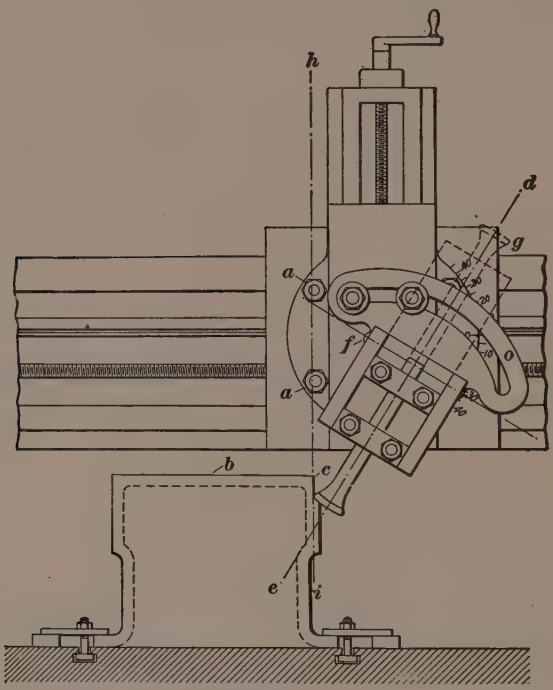

FIG. 30

are perpendicular to the table. The zero mark on the swivel plate should be in line with the setting mark on the saddle when the swivel plate is vertical; but it is apt to be thrown out of true in a number of ways. Hence, if the head is not set correctly, the nuts *a*, Fig. 30, are loosened and the swivel plate is turned until the graduations coincide properly and the nuts are then tightened. A finishing cut is now taken over the top surface *b*, after which a side tool is substituted and a finishing cut

is taken down the side surface *c*. A try square is applied to the top and side surfaces *b* and *c* and if they are not square with each other, the swivel plate is readjusted and another trial cut is taken down the side face. This is repeated until the side face becomes square with the top, and the head is then perpendicular to the table.

56. Effect of Swinging Apron Box.—The top of the apron box and tool block must always be *inclined away* from a side surface that is being planed, so that the tool will swing away from the work on the return stroke. This is shown in Fig. 30, in which the apron box is swung over until the shank of the tool slants away from the vertical face *c*, as indicated by the dotted line *d e*. If the tool is lifted, the tool block will swing on the pin *f*, and the tool will move farther and farther from the work until, when in the dotted position shown at *g*, it will be a considerable distance from the line *h i* that denotes the vertical along the face *c*. If the apron box were inclined in the opposite direction, the tool would rise and swing into the work on the return stroke and the work or the tool, or both, would be damaged. If the tool must rise squarely, without swinging to either side, as would be the case when a slot is being planed, the apron box must be set central with the down-feed slide.

57. Direction of Feed for Side Cuts.—The tool used in a cross-rail head for making roughing side cuts is usually fed down. The reason for this is that the lines indicating the position of the cut can be drawn only on the top, or if the tool is set by measurement the rule or gauge can be applied only on the top. The tools, consequently, are made so that they must be fed down when roughing. It would also be difficult to get the tool into a position to start a cut and feed up, and if it were tried the tool would catch in the stock above during the return stroke and be broken or shifted from position. Finishing cuts, however, if made with the rounded corner of the broad-nose squaring-down tool, shown in Fig. 5 (*a*), can be fed up, provided the tool can be set and started on the up feed from slightly below the lower edge of the surface to be finished. The feed would be about the same as that used for the down

roughing cut on the same surface and the thickness of metal removed would be between $\frac{1}{64}$ and $\frac{1}{32}$ inch.

58. The finishing cut made with a side tool, shown in Fig. 8, is very thin, as but 3 or 4 thousandths of an inch in thickness is removed and that with a coarse feed. The side tool should be set to feed down and then fed down. If a slightly greater depth of metal is required to be removed or a better finished surface is called for the feed may be reversed and the tool fed up without changing the setting of the tool sidewise. The tools used in side heads can be fed up or down, as the work is usually set to clear the table at the bottom by projecting over the side or being blocked up. It is usually better to feed the side head up as all backlash between the feed-screw and the nut is taken up by the weight of the head.

T SLOTS AND UNDERCUTS

59. Planing T Slots.—The first step in planing a T slot is to cut a plain slot having a width *a*, Fig. 31, equal to that of the open part of the T slot and a depth equal to the depth of the finished slot. A tool *b* is then clamped in the tool block and is set so that its edge *c* is perpendicular to the table. The whole thickness *d* of the cutting part and the shank, at the bottom, must be less than the width *a* of the plain slot. This tool is run down until its lowest point scrapes the bottom of the slot lightly. It is then fed crosswise so as to cut one side of the T slot, as shown by the dotted lines *e*. When this is finished, a similar tool with a cutting edge facing the other way is used to cut the opposite side of the T slot. The down-feed slide is clamped while these parts of the slot are being finished; or, if no clamping device is provided, its screw is turned backwards

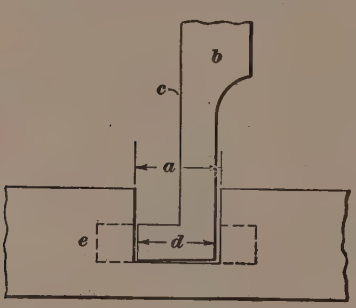

FIG. 31

until all backlash is taken up, so that the tool will not dig into the bottom of the slot.

60. Lifting Tool in T Slotting.—When planing the undercut sides of the T slot, the stroke is made longer at each end, and when the tool runs out at the end of the cutting stroke, it is lifted by hand while the table makes the return, to prevent damage to the tool or to the work. The feed is operated during the return stroke, and the tool is dropped for another cut as the reverse occurs. If it is inconvenient or impossible to raise the tool during the return stroke, a block or a jack *a*, Fig. 32 (*a*),

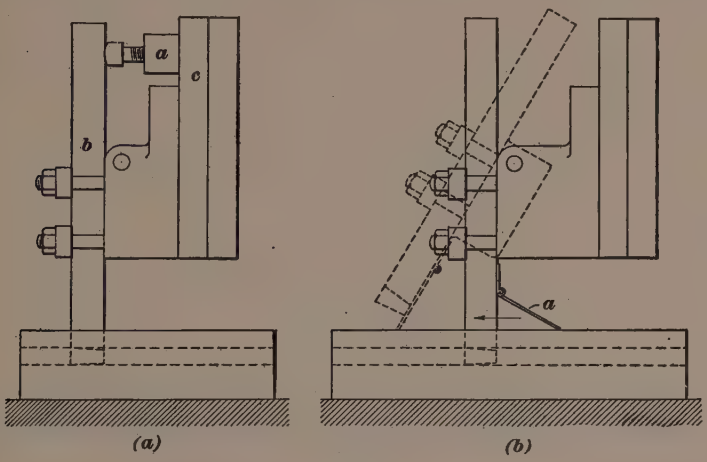

FIG. 32

may be placed between the top of the tool *b* and the down-feed slide *c* to hold the tool rigidly. When so held, the feed must occur just after the return stroke, and before starting the next cut. The tool may be lifted automatically by attaching a sheet-metal hinge to its back, as shown in (*b*). On the cutting stroke, the flap *a* drags along over the surface of the work, as indicated by the full lines. At the end of this stroke, it drops down behind the tool, so that, on the return stroke, it rides on the work and lifts the tool, as shown by the dotted lines. At the end of the return stroke it runs off the work and drops the tool into position for another cut. A small rope fastened to the shank of the tool and run over a pulley suspended above the

planer table will enable the operator to lift the tool by hand without any great effort.

61. Undercuts.—The tool used for undercutting is similar to that used for cutting T slots, but it is larger and stronger.

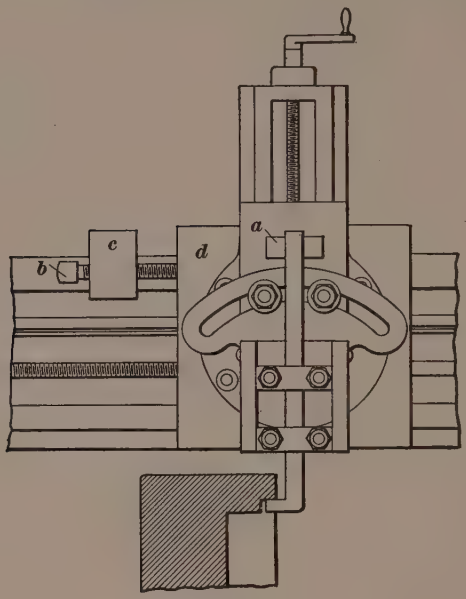

FIG. 33

Tools for undercutting are more subject to chattering and should therefore be mounted very rigidly. If inserted tools are used, they should be supported by a solid shank and they should have a minimum of overhang. It is sometimes necessary to make undercuts where both ends of the work are closed. A convenient method of doing this is to put a block between the tool shank and the head as shown at *a*, Fig. 33, and then to secure a stop-screw *b* to the face of the cross-rail by means of a suitable clamp *c*. The tool is fed to the work after the dogs on the table are set to give correct length of stroke and while it is cutting the stop-screw is brought up to the saddle. When the cut is completed the tool is quickly run out of the cut by moving the head along the cross-rail, after which the stop-screw is turned

back slightly. The head *d* is fed up against the stop-screw at the beginning of the next cut, and these operations are repeated. The object of running the tool out of the cut on the return stroke is to project its edge and insure a smoother surface on the work. This method can be used when cutting T slots that are closed at one end or that are in narrow places where it would be inconvenient or impossible to lift the tool out of the cut during the return stroke.

PLANING CURVED SURFACES

62. Planing Curved Surfaces in Top of Work.—A curved surface may be planed crosswise in the top of the work by the rig shown in Fig. 34. A special long head *a* is pivoted at the

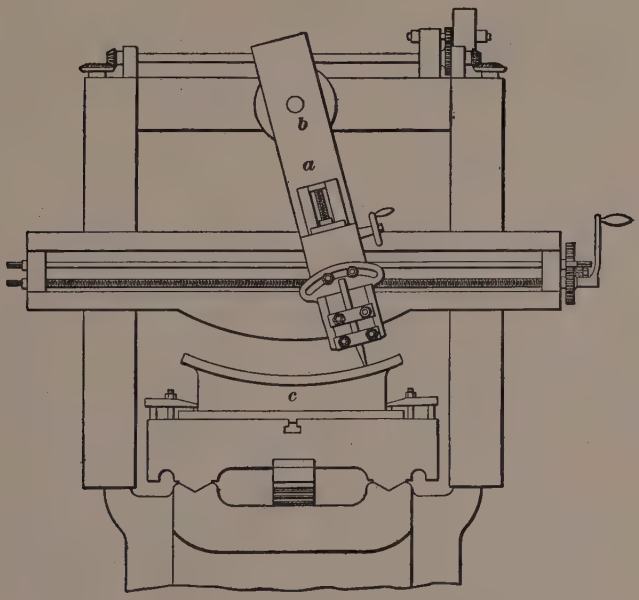

FIG. 34

point *b* and the distance from the point of the tool to the point *b* is made equal to the radius of the curve to be planed on the work *c*. The regular down-feed slide is attached to the lower end of the special head, which is gibbed to the curved

part of the special cross-rail so that it can slide freely as it swings about the center *b*. In operation, the cross-feed motion is used as in ordinary planing and the tool is adjusted to the work by the regular down feed.

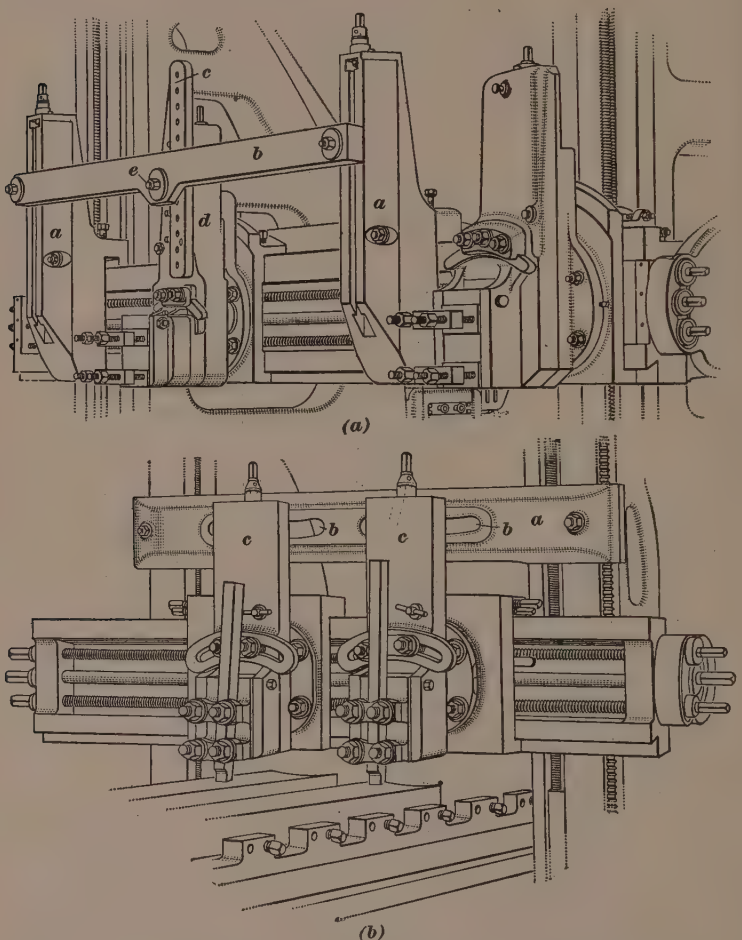

FIG. 35

63. Small curved surfaces in the top of the work may be planed easily by a special adjustment of the apron box. The tool is set so that the distance from its point to the center of

the pin on which the apron box swings is equal to the radius of the curved surface to be planed. The tool point is then set central over the work, to bring the center of the head directly over the center of the curve to be planed. The screws holding the apron box in position are adjusted so that the apron box can be rapped over slightly with a wooden mallet to give the feed at each stroke. The cut is then started at one edge of the work and the tool is fed across by rapping the apron box. Some apron boxes have the top of the casting over the circular slot cut with worm-gear teeth and a worm provided on the down-feed slide to do the feeding.

64. A fixture that can be used for planing curves of different radii in the top of the work is shown in Fig. 35 (*a*). Two brackets *a* are clamped to the cross-rail, and a horizontal bar *b* is attached to the vertical feed-screws in the brackets. The swinging arm *c* to which the tool slide *d* is fastened has a number of holes throughout its length, any one of which may receive the bolt *e* in the bar *b*, thus making it possible to give the arm *c* different lengths. The tool slide *d* thus is compelled to swing in an arc of a circle about the bolt *e* as a center when the cross-feed screw moves the head.

Another method of planing a crowned or hollow surface crosswise on narrow work is to use a guide rail *a* mounted above the cross-rail, as shown in Fig. 35 (*b*). A horizontal slot *b* having the same crown or hollow as required on the work receives a roller attached to the down slide *c*. Then as the head is fed across the work the tool is raised and lowered to produce the same curve on the work as that on the slot *b*.

65. Planing Tapered Circular Work.—A fixture for planing tapered circular work is shown in Fig. 36. The lower half of the work *a* has been planed, and the part above the two wings *b* is being operated on. The ends have been turned cylindrical and these are supported in a headstock *c* and a tailstock *d*. The headstock has a hand wheel *e* for operating the clutch *f*, and there is a worm-gear on the outer end of the headstock for revolving the spindle and the work as required for the circular feed. The worm is revolved by the crank *g*; or the feed

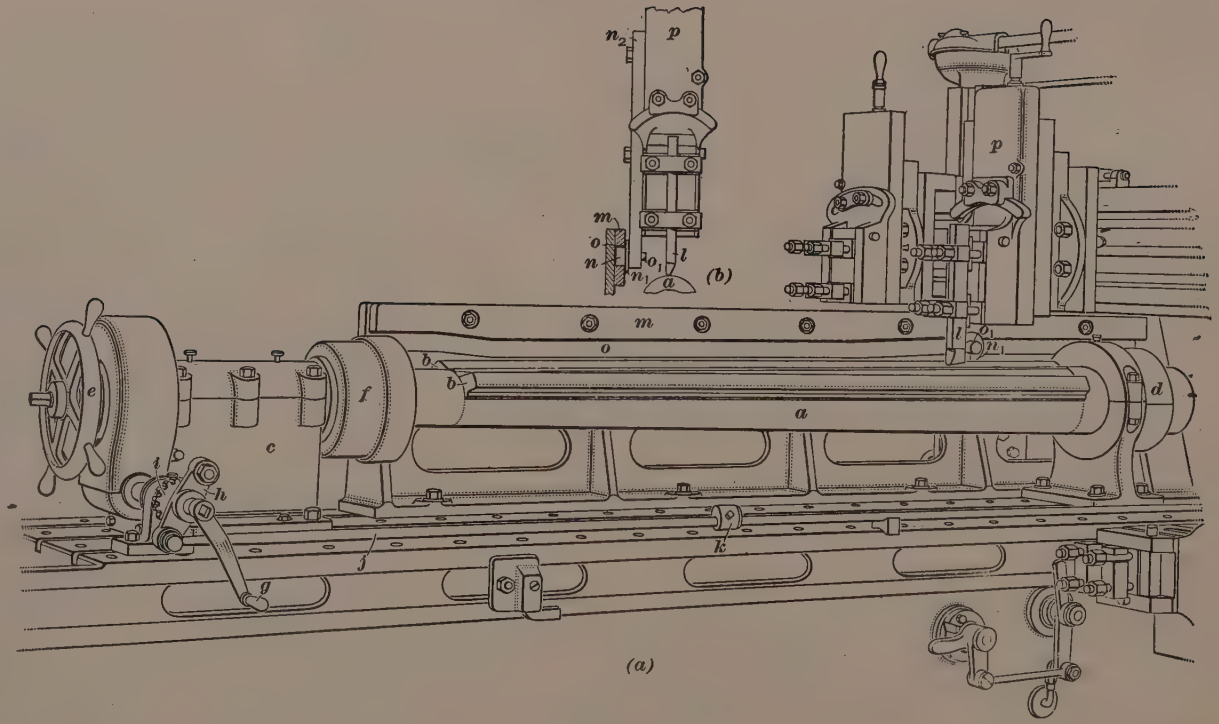

FIG. 36

may be operated automatically by the arm h as the ratchet i is moved back and forth by the long rod j. Stop collars, as at k, are located on the rod and engage a dog or dogs attached to the inside of the housing. The taper is greater at the large end of the work than at the small end, and the tool l is moved vertically to give the required shape of the work by the use of a

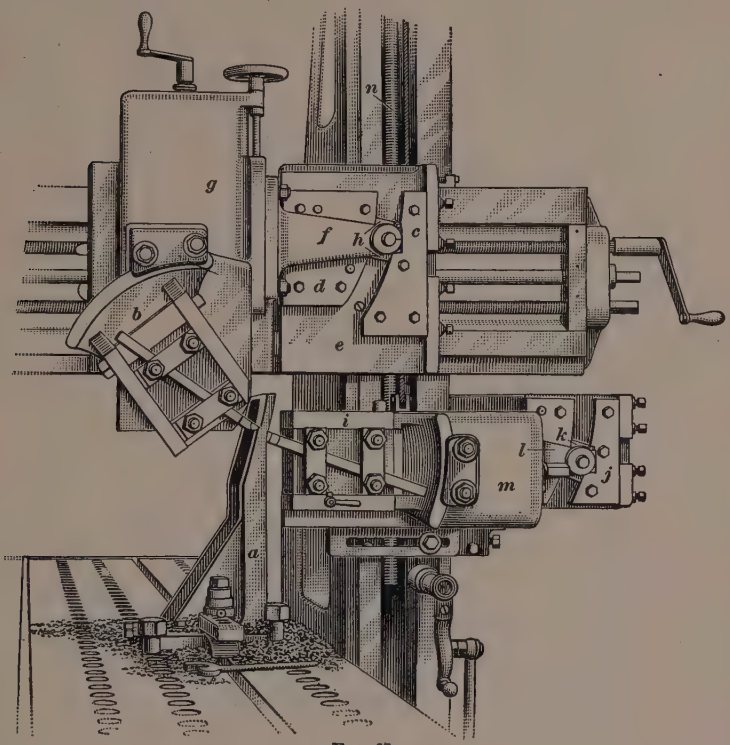

FIG. 37

long guide, or cam, m bolted to the table. A roller n fits in the groove o in the cam, and a bar fitted to the roller stud is attached to the tool slide p. The arrangement is such that the tool is raised or lowered as may be required during each stroke of the table.

66. Planing Vertical Curves on Side Faces.—The fixtures for planing two curves at the same time on the side faces of a

piece are shown in Fig. 37. The inside, or hollow, curve on the work *a* is planed by the head *b* on the cross-rail. A grooved cam is formed by attaching two plates *c* and *d* having curved edges to a base *e* that is clamped to the cross-rail. A bracket *f* attached to the tool slide *g* carries a curved block *h* that fits in the groove of the cam. The head is released from the cross-feed screw, so that, when the tool is fed down by the slide screw, the cam moves the tool horizontally. The outside curve on the work *a* is planed by the side head *i* using a cam *j* attached to the outside of the housing. In this case the curved block *k* and the bracket *l* move the tool slide *m* horizontally while the feed-screw *n* moves the head vertically.

67. Planing Curved Side Faces.—A curved side face may be planed by the use of the rig shown in Fig. 38 (*a*) and (*b*). A flat plate *a* is clamped or bolted to the planer table and in it is fixed the stout pin *b*. On the plate *a* is a work table *c* having a long slotted arm that projects squarely beyond the table and is pivoted on a pin *d* held by the floor support *e*. The distance from the center of the pin *d* to the curved side face of the work *f* is equal to the radius of the curve of the face. The outer end of the slotted arm slides freely on the support *g*. The pin *b* projects upwards through a slot in the work table *c*, and as it moves back and forth with the planer table, the work table is swung around the pivot *d*. At the same time, the work table has a slight motion across the plate *a*, and for this reason the slot for the pin *b* is long in a direction across the table.

68. The ends of the work table *c*, Fig. 38, are curved with a radius equal to half the length of the work table between the gooseneck clamps *h*. These clamps are bolted to the planer table and keep the plate *a* from moving lengthwise; also, their upper flanges extend over the edges of the work table, so that it may turn or slide beneath them but cannot rise off the plate *a*. The work *f* is bolted to the work table *c*, so that as the planer table moves to and fro, the pin *b* on the plate *a* carries the work table lengthwise, and the pivoted slotted arm swings it so that the work is given the correct movement beneath the tool. A squaring-down tool is used and is fed vertically downwards.

69. Planing Helical Grooves.—In order to plane a helical groove in a piece of work, such as a shaft, it is necessary to give two motions to the work. One is a lengthwise motion and the other a turning motion of the work on its axis. The arrangement shown in Fig. 39 (*a*) and (*b*) may be used for

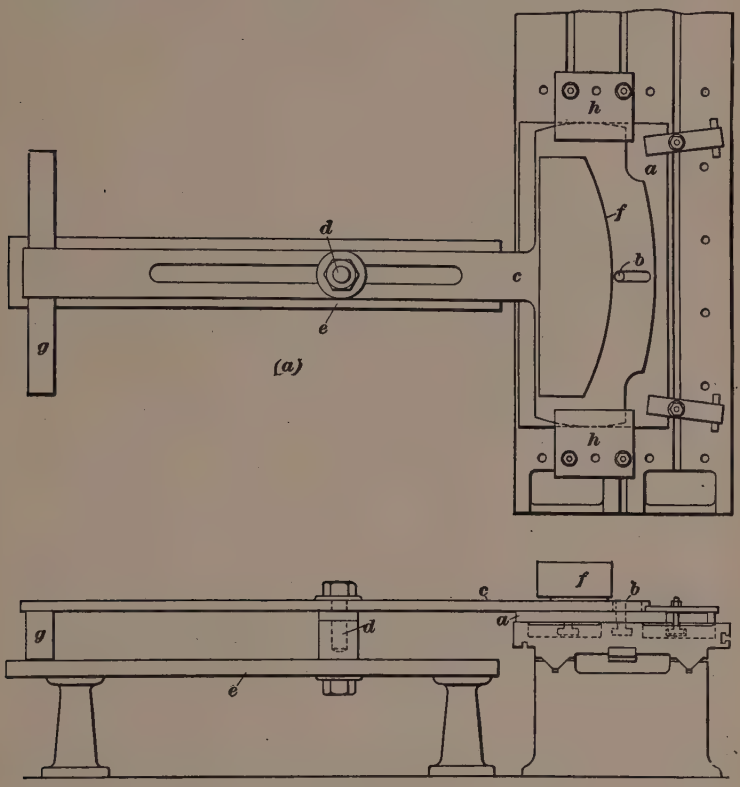

FIG. 38

planing a helical groove. The shaft *a* in which the groove is to be cut is held at one end in a chuck *b* connected to a worm-gear *c* that is supported by the head *d*. The other end of the shaft is held in the tailstock *e*. The worm-gear is driven by a worm *f* that receives motion through the gears *g*, *h*, *i*, and *j* from the pinion *k*, which meshes with a rack *l* fixed to the bed

FIG. 39

of the planer. Both the head *d* and the tailstock *e* are bolted to the table of the planer, and thus the shaft *a* is given the required lengthwise motion under the tool. The pinion *k* is rotated by engaging with the stationary rack as the table moves to and fro, and thus the worm-gear *c* is turned, causing the shaft *a* to rotate, and thus insuring a helical groove. The angle of the groove may be altered by changing the sizes of the gears *h* and *i*, which are mounted on an adjustable stud.

PLANING BEVELS

70. Swinging of Head.—When a beveled cut is to be made, that is, a cut at an angle of less than 90° to the surface of the table, the swivel plate is swung so that the center line of the down-feed slide is inclined at this angle. In addition, the tool block and the apron box must always be swung so that the shank of the tool slopes away from the surface to be planed, so that the tool will rise from the work on the return stroke.

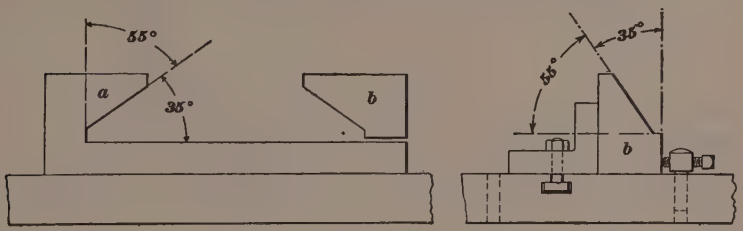

FIG. 40

71. Setting Swivel Plate to Any Angle.—In Fig. 40 (*a*) is shown a piece of work having bevels to be planed. The fixed side *a* has a face inclined at 55° to the vertical and 35° to the horizontal. If the planer head is graduated from zero in each direction, then, to plane the bevel of the side *a*, the swivel plate should be swung until the 55-degree graduation is even with the zero mark on the saddle. The down-feed slide will then make an angle of 55° with the vertical and the bevel will be planed correctly. If the planer head is graduated from 90° in each direction, the swivel plate must be swung until the 35-degree graduation is in line with the zero mark on the saddle, in order

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to plane the bevel on the side *a* of the piece. The loose side *b*, called the *gib*, is to be planed at the same angle as the side *a*. It is usually set against an angle plate, as shown in (*b*). Then, if the planer head is graduated from zero, the swivel plate is swung until the 35-degree mark is in line with the zero on the saddle; but if it is graduated from 90°, the swivel plate is swung until the 55-degree mark is in line with the zero on the saddle.

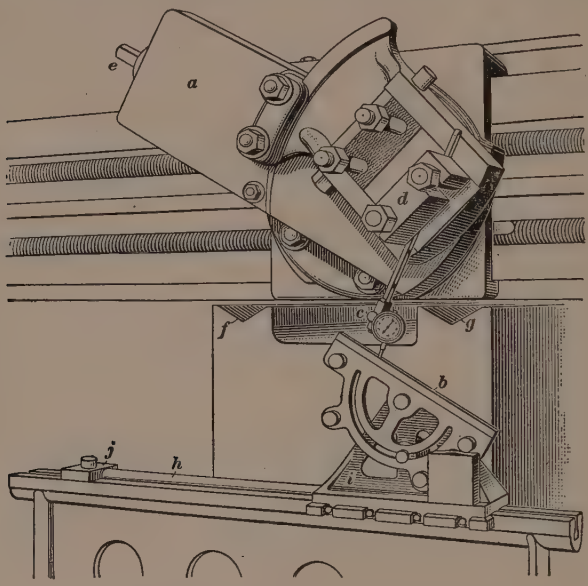

FIG. 41

72. Use of Sine Bar When Planing Angular Work.—The tool slide may be set to any required angle and the accuracy of the work tested by the use of the sine bar, as shown in Fig. 41. In order to plane the same angle on the work as that to which the sine bar is set, it is necessary to set the tool slide *a* parallel to the straightedge *b* of the sine bar. To make this setting, the slide *a* is swiveled over to as near the correct position as can be judged by the eye. Then a dial gauge *c* is fastened in the lower tool clamp *d* and its pointer is brought in contact with the straightedge *b*. By means of the feed-screw *e*, the slide and the dial gauge are moved along the straightedge and any change in

the reading of the gauge is noted. If there is no change, the setting is correct; otherwise, the slide must be shifted and the test on the straightedge repeated.

73. After the tool slide is set parallel to the sine bar, as shown in Fig. 41, the angle planed on the work, such as the angle of the ways f and g of a planer bed, may be tested by locating the pointer of the dial gauge c on the surface f and noting the dial reading when the pointer is moved along the surface. The spacing of the ways f and g can also be tested. Suppose that their center-to-center distance is to be 24 inches; a 24-inch bar h is placed against the pedestal i and a stop j is clamped against the other end of the bar, as shown. Next, the bar h is removed and the pedestal is moved over against the stop. The tool head is shifted along the cross-rail until the pointer of

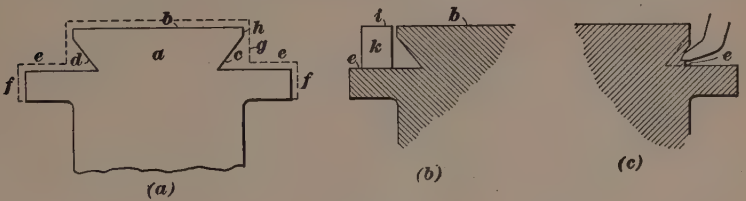

FIG. 42

the gauge c rests on the surface f of the way, after this surface has been moved forwards under the pointer by the motion of the planer table. The reading on the dial gauge should be the same as when the pointer bears on the surface g, and should show no change when shifted by the tool slide along the surfaces f and g.

74. Planing Dovetails.—If two machine parts are to be dovetailed so as to fit without adjusting gibs, the work must be done very accurately. A dovetailed part that is to fit a corresponding groove is shown at a, Fig. 42 (a). The two parts are to bear, or touch, along the surfaces b, c, and d. The rough casting has the shape indicated by the dotted lines, and the first operation is to take roughing cuts over the surfaces b, e, and f, which is usually done with a round-nosed tool having no side rake, so that it can be fed either way. The bottom surface of

the casting, not shown in the illustration, is then roughed and finished and the piece is carefully reset on this finished surface, after which the upper surfaces are finished. A square-nosed tool is used to finish the horizontal surfaces *e* and *b*; the tool may be first set to the lower surfaces *e* and both of them finished. In order to obtain the correct distance between the upper and lower surfaces *b* and *e*, it is well to use a size block *k*, as shown in (*b*). This is set on the lower surface *e*, and when the planer tool is adjusted to the upper face *i* it will be set right for finishing the top surface *b*.

75. After the horizontal surfaces *b* and *e*, Fig. 42 (*a*), have been finished, the stock must be roughed out in front of the inclined surfaces *c* and *d*, as shown in (*c*). A roughing tool of the form shown in Fig. 43 (*a*) is used. The cutting is done by

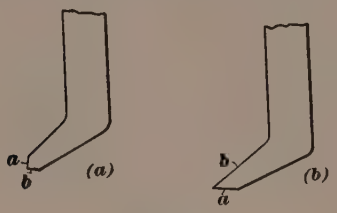

FIG. 43

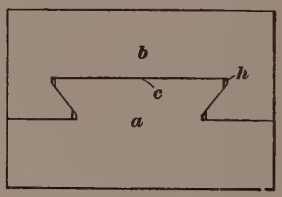

FIG. 44

the faces *a* and *b* and the tool is ground with little or no top rake and with no side rake. The planer head is set over to the required angle and the stock is removed by successive cuts, as shown in Fig. 42 (*c*), in which the dotted outline shows the required form of the groove. After all the stock has been roughed out, the portion of the lower surface *e* that is under the dovetail, and hence could not be finished by the square-nosed tool, is finished by a tool of the form shown in Fig. 43 (*b*). This tool is practically an offset square-nosed finishing tool, the cutting being done by the bottom face *a*. The top face *b* is cut away so that it can work under the bevel surface of the dovetail. The beveled surfaces *c* and *d*, Fig. 42 (*a*), are finished with an ordinary side tool using a fairly coarse feed. The work on the first beveled surface should be completed before work is begun on the second.

76. A gauge like that shown in Fig. 44 is often used in laying out the dovetail. The two parts *a* and *b* of the gauge are fitted accurately to each other. The portion *a* is laid against the end of the work and a line is scribed around it before any undercutting is done. After the beveled surface *c*, Fig. 42 (*a*), has been completed, the head is swung vertically and the side tool is used to finish the edge or corner *h*, Fig. 44, perpendicular to the top surface *c*. It is important to do this at the same setting at which the other faces are finished, as frequently the face *h* is the only surface to which the workman can refer in making measurements for fitting the work; and if the bearing surfaces become injured or worn and require redressing, the surface *h* is usually the only one by which he can set the casting accurately for refitting.

77. After one side of the dovetail has been finished, the other side is planed in a similar manner, the tools used being similar to those shown in Fig. 43 (*a*) and (*b*), but forged to the opposite hand. From this it will be seen that for planing a dovetail it is necessary to have one or more roughing tools, a set of offset right-hand and left-hand tools for working under the angles, and right-hand and left-hand side tools. In planing the second side of the dovetail, the external portion *b* of the gauge shown in Fig. 44 is sometimes employed by setting one beveled edge of it against the finished edge of the work at the end and scribing inside of the other beveled edge, though usually the roughing and first finishing cuts are taken to the lines laid out with the external part *a*, and the internal part *b* is used only for testing the fit of the work during finishing. If the side *c*, Fig. 42 (*a*), is planed first, the final fitting is done on the face *d*. Sometimes, in place of fitting the work to a gauge, the final fit is made by using as a gauge one of the pieces that is to work on the slide *a*. Of course, in planing where no gib is used, no attempt should be made to make the pieces work together freely, as some stock must always be left for the fitter to remove when fitting the pieces. If the piece can be pushed on or driven on for from $\frac{1}{8}$ to $\frac{1}{4}$ inch, it can be fitted to slide freely.

78. Frequently, especially in heavy work, parts that are joined by dovetails similar to those shown in Fig. 42 (*a*) are not fitted directly to each other, but a gib is introduced, as shown at *c*, Fig. 45. The dovetailed pieces *a* and *b* are planed and fitted together in a manner similar to that already described, except that both pieces are fitted to a gauge similar to that shown in Fig. 44. After this a gib *c*, Fig. 45, is planed to fit between the pieces, and is held in place by means of setscrews, as shown at *d*. The points of the setscrews fit into recesses opposite the center of the gib. This arrangement allows considerable adjustment for taking up the wear between the surfaces on the pieces *a* and *b*; also, it simplifies the planing considerably, as the fit is already made on the gib *c*. This form of gib is often used in machine construction.

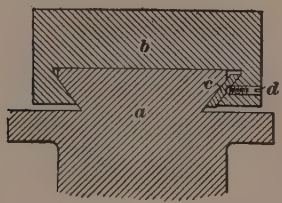

FIG. 45

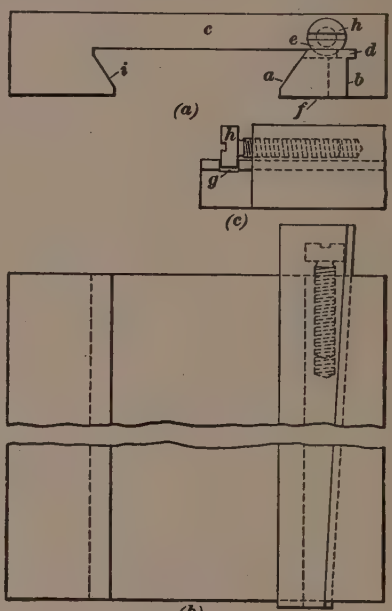

FIG. 46

79. Planing Taper Gib.—A taper gib such as is used in machine construction is shown in Fig. 46 (*a*), (*b*), and (*c*). The beveled surface *a* of the gib fits against the under face of the dovetail and the back face *b* is tapered, a similar taper being formed in the slide *c* as shown in (*b*). The gib has a tongue *d* that fits a corresponding groove in the slide and prevents the slide from lifting when in use. The top and bottom surfaces *e* and *f* of the gib are parallel and across the top, as shown in (*c*), is cut a slot *g* in which fits the lower part of the

head *h* of a setscrew. By screwing the adjusting screw into the slide *c*, the gib is forced in, and all backlash between the slide *c* and the dovetail is taken up.

80. When a taper gib and a slide are required, it is best to plane an ordinary parallel to a taper corresponding to the taper of the gib, and of the same length. This is called a *taper parallel*. It serves as a form against which the gib and the slide are held while the taper is being planed. The slide is previously planed to shape until all surfaces except the taper surface *b*, Fig. 46 (*a*), are finished. The outside edge of the slide is then set against the taper parallel, which is held against a parallel strip on the planer table, and is clamped in place. This brings the surface *b* parallel to the line of motion, and the surface *b* and the bottom of the groove for the tongue *d* are then planed to fit the back surface *b* and the tongue of the gib, or so that the gib will slide freely into place.

81. The gib is roughed out from a piece of rectangular stock, which is planed down to a thickness equal to the distance between the top and bottom faces *e* and *f*, Fig. 46 (*a*). It is then set with its top face *e* against a parallel strip or the fixed jaw of a vise and the back face *b* and the tongue *d* are planed true and square with the bottom *f*. The surface *f* of the gib is next fastened against the parallel strip with the taper parallel underneath and supporting the face *b*, and in this position the beveled surface *a* is planed, the head being set to an angle equal to 90° minus the angle at which it was set to plane the angular face *i* on the other side.

82. When the gib has been completed thus far, the slide is put in place on the cross-slide which it is to fit, and the gib is marked from them, to determine how much metal must be removed to make it enter. The bevel is roughed nearly to size and is finished by taking a number of light cuts over the bevel surface. It should be chalked with lengthwise and crosswise lines when it is being tried in place, and it should show a good bearing by having the chalk evenly rubbed off on all of the surfaces to which it must be fitted. It may be planed down until

the small end comes flush with the end of the slide, or it may be left $\frac{1}{16}$ inch or more short of the end, as it will pass in farther when it is fitted. After the gib is brought to its working position, the groove for the head of the adjusting screw is marked off and cut, thus completing the gib. If a number of slides are to be planed at one time, it is usual to make as many taper parallels as there are slides.

PLANING LARGE WORK

83. Planing Work Longer Than Table.—If a piece of work is much longer than the planer table, the projecting end is supported on rollers. As much as possible is planed with the piece in this position, after which the work is shifted along the table and the remainder of the piece is planed. Considerable skill is required to reset the work and get the second part planed true with the first one.

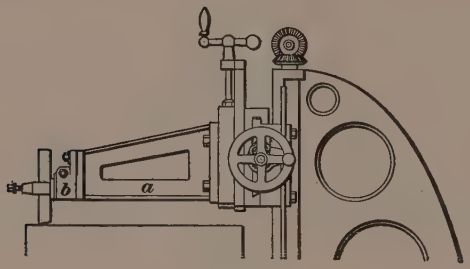

FIG. 47

84. Planing Work Too Wide for Housings.—If the work is too wide to go between the housings and is not very long, an extension head *a*, Fig. 47, long enough to reach over the work when the latter is close to the housings, may be fixed to the down-feed slide. The tool block *b* is fixed to this extension. This device cannot be used for very heavy cuts.

85. Use of Floor Stands for Large Work.—Very wide work, such as the pair of planer housings *a*, Fig. 48, may be planed by using the independent housings, or floor stands, *b* and *c*. These are bolted to the slotted floor plates *d* and stand in front of the regular housings and cross-rail of the

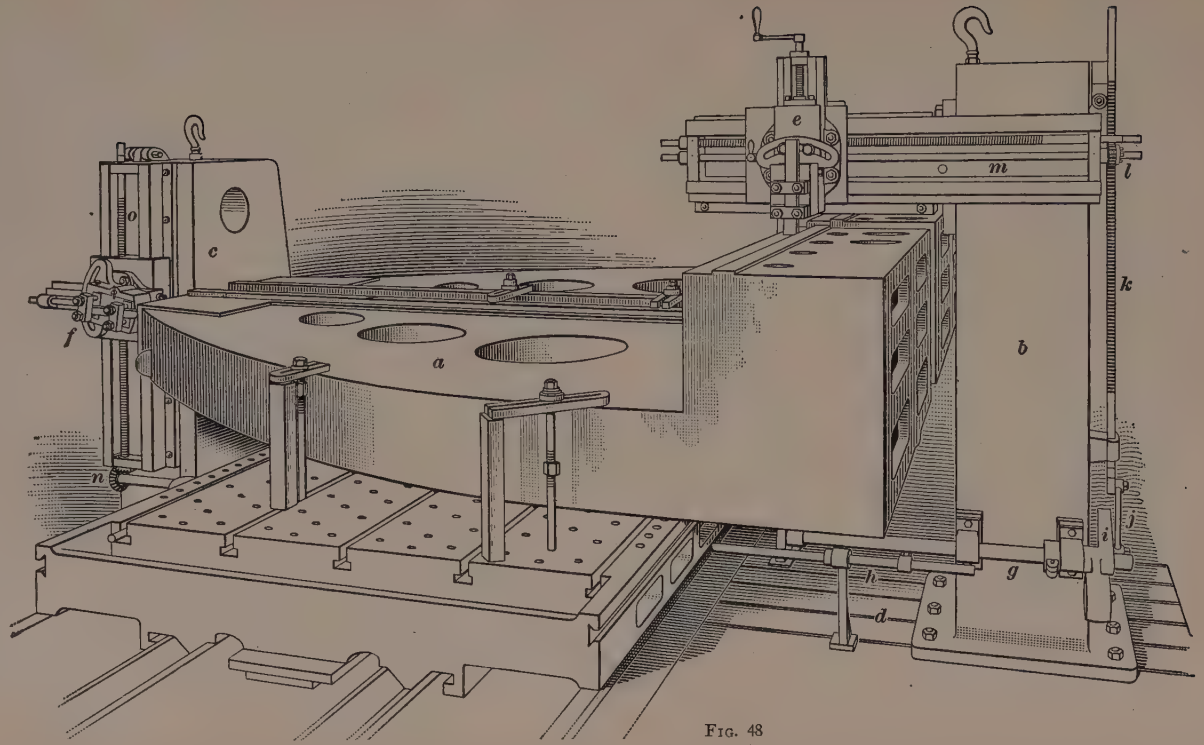

Fig. 48

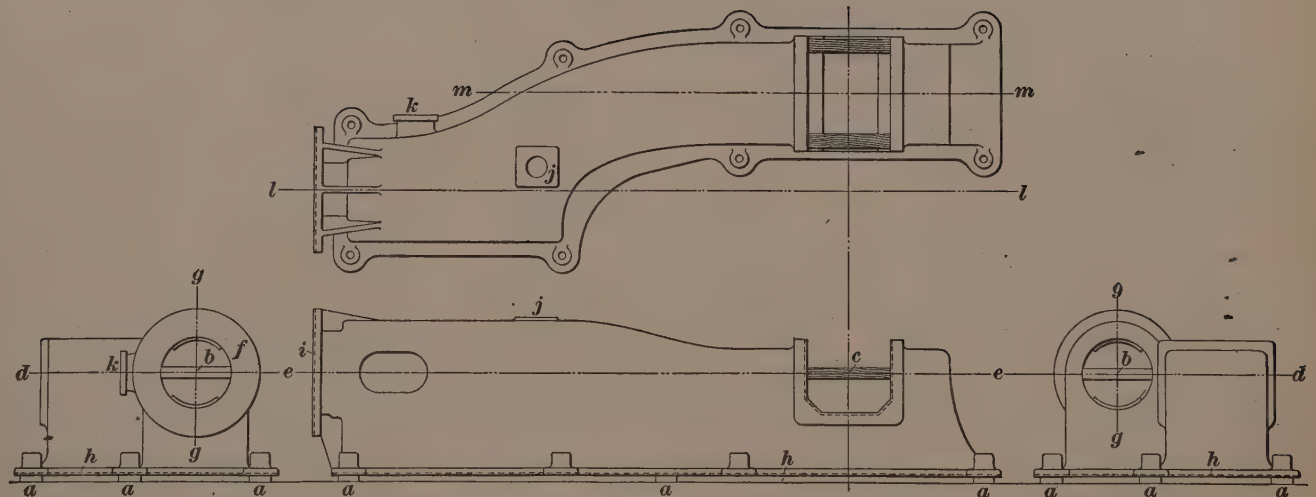

FIG. 49

planer. The tool heads *e* and *f* are similar to those used on the planer, and their power feeds are operated by the use of extension rods *g* and *h* that receive their motions from the table dogs. Thus, when the dog on the edge of the table strikes a trip on the rod *g*, this rod is given a part turn, and its motion is transmitted through the arm *i*, rod *j*, and vertical rack *k* to the pinion *l* on the feed-rod *m* for the head *e*. For the head *f*, a table dog strikes a trip on the rod *h*, which transmits its part turn by means of bevel gears *n* to the vertical feed-screw *o*.

86. Laying Out Engine Bed.—The first step in preparing to plane a piece of large work, such as an engine bed, is to lay out the work. The bed is placed on parallel blocks *a*, Fig. 49, on the planer table or a laying-out table, and is leveled so that the center *b* of the guides and the center *c* of the shaft in the main bearings are at the same height above the table; also, the center line *b d* through the guides and the main bearing is leveled. The centers in openings are located on strips of wood driven in the openings. The surface is then chalked and lines, as *e e*, are drawn with a surface gauge on both sides and ends of the bed, at the height of the center line *b d*. The center of the guides is located on the block driven in the cylinder end *f* and the vertical line *g g* crossing the center is drawn by the use of a square. A bottom finishing line *h*, shown dotted, is drawn at the given distance below the center line and all the details such as the cylinder end *i*, the main bearing, and the pads *j* and *k* are laid out. The top center lines *l l* and *m m* are located by a chalk line or by setting the bed on edge and using a surface gauge, after which the bed is ready for planing.

87. Planing Engine Bed.—The engine bed is placed bottom side up on the planer table, and is leveled so that the lines *e e* and *b d*, Fig. 49, are at the same height from the table, this being done by the use of a surface gauge, as shown in Fig. 50. Blocks *n* are placed under the cylinder end and the main bearing and clamps are applied above these supports. Jacks and stakes are used to prevent the work from moving, and then roughing and finishing cuts are taken over the whole bottom, to the depth indicated by the line *h*. The bed is then turned over on this

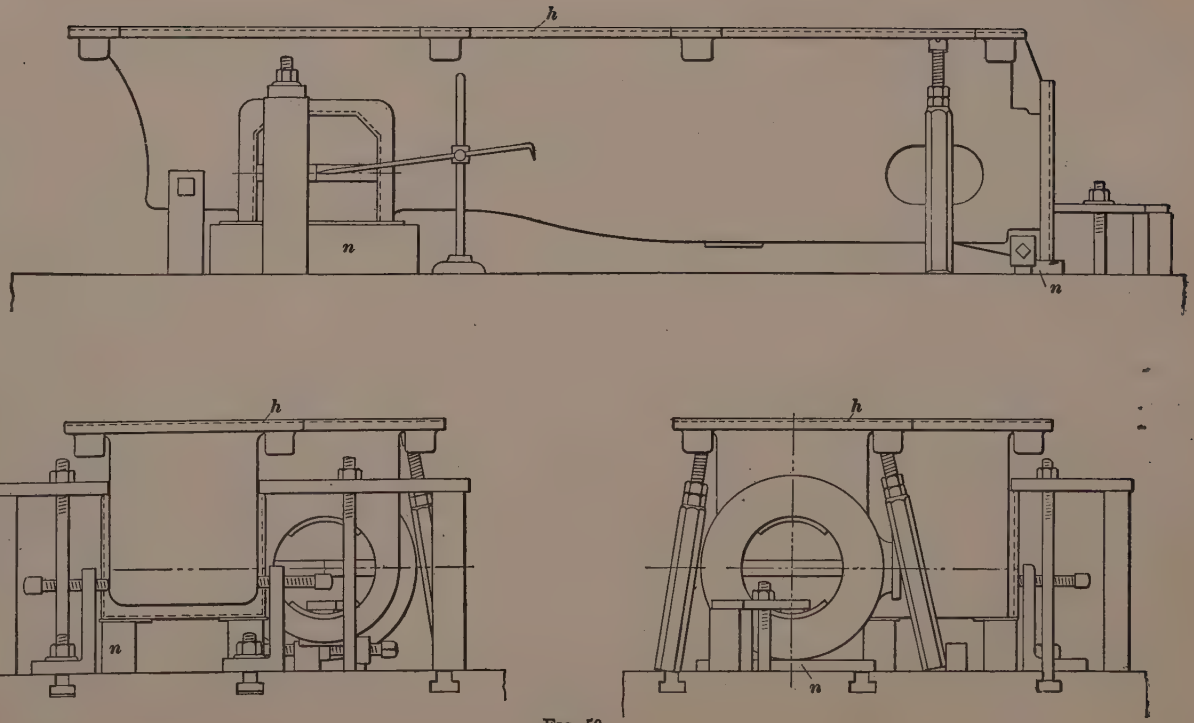

Fig. 50

finished surface and the center lines *l l* and *m m*, Fig. 49, are lined up with the direction of motion of the table, after which the pads *j* and *k* and the ends and top of the main bearing are planed. It is then turned at right angles to the table and the inside faces of the main bearing are planed. During the last operation, the end of the engine bed will extend beyond the side of the table and must be supported by a parallel piece well oiled. An extension holder is required for planing the jaws of the main bearing, and a long tool holder for planing down the ends of the bearing.

88. Planing Lathe Beds.—A lathe bed that is to be planed is first placed upside down on the planer table and is leveled

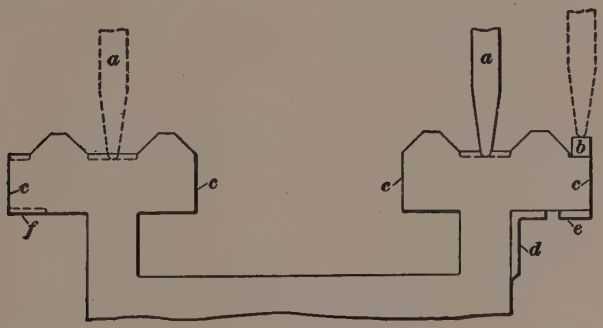

FIG. 51

until the under surface, on which the **V**'s are to be cut, is parallel with the table. It is then clamped and a roughing cut and a finishing cut are taken over the pads against which the legs are to be bolted. It is next turned over, paper strips are put under the planed pads, and it is set so that the **V**'s are parallel to the line of motion of the table. The flat parts of the bed beside the **V**'s are first roughed out with a round-nosed tool *a*, Fig. 51, to the depth indicated by the dotted lines. A size block *b* of the proper height is used to set the tool for cutting off the tops of the **V**'s. The same tool may be used to cut a number of grooves along the slanting faces of each **V**. This breaks up the scale and less work is put on the roughing tool that is used to form the **V** surfaces.

89. The distance between each pair of **V**'s may be laid off by using the marking jig *a*, Fig. 52 (*a*). The two marking punches have cupped ends and are spaced at the correct distance. The jig is placed across the planed tops of the **V**'s and adjusted by the screws *c* until the punches are central over the flat tops of the **V**'s. Each punch is then struck with a hammer, and the cupped ends leave two circles *d* on the tops of the **V**'s, as shown in (*b*). A similar gauge may be used to mark the other pair of **V**'s, or one gauge may be made to mark all four.

90. The roughing tool for forming the **V**'s for small beds is made as at *a*, Fig. 53 (*a*), but both right hand and left hand,

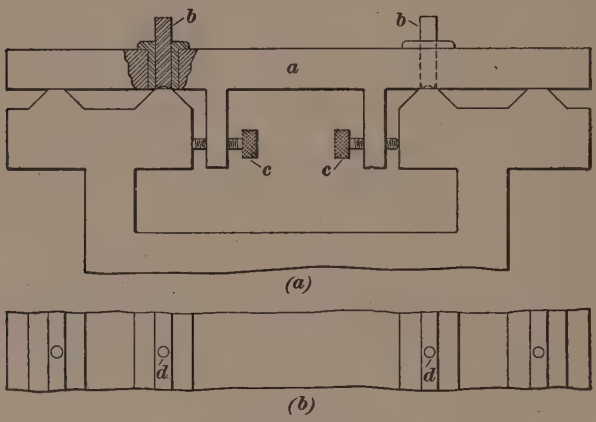

FIG. 52

and is set to the correct angle by the use of the **V** gauge *b*. It is then fed from each side until it just touches the circle *d*, Fig. 52 (*b*). Large beds are planed by using a square-nosed tool and the down feed. After the inclined faces are planed, the spacing of the **V**'s is tested by bringing the inclined faces of the **V** gauge against them, as shown in Fig. 53 (*b*). Paper strips are put between the gauge and the work to determine the accuracy of the fit. The side surfaces *c*, Fig. 51, are next squared down, and such undercuts as the rack seat *d*, the pads *e* for the lead screw and feed-rod, the seat *f* for the back gib of the carriage, and the seat for the taper attachment are planed, if

they can be reached by side heads or tool holders; if not, the bed is reset on its side and they are then roughed out.

91. Gauge for Spacing V's.—The spacing of the **V**'s on lathes and other machines must be very accurate; therefore, a

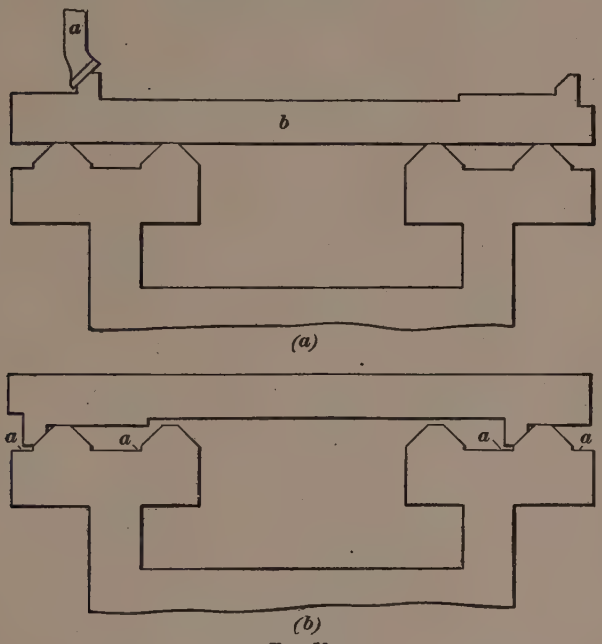

FIG. 53

gauge like that shown in Fig. 54 is used, as it will test each side of the **V**'s separately. The gauge is finished all over, and the gauging surfaces *a* and *b* are planed at the required angle of

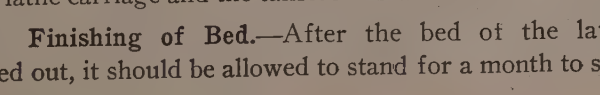

FIG. 54

the **V**'s. This gauge can be tried on only one side of the **V**'s at one time and it may be used to gauge the ways or grooves of the lathe carriage and the tailstock as well as those of the bed.

92. Finishing of Bed.—After the bed of the lathe is roughed out, it should be allowed to stand for a month to season,

before it is finished. For the finishing operation, it should be lined and clamped in the planer as for roughing. The top surfaces *a*, Fig. 53 (*b*), are then planed with a narrow finishing tool and the tops of the **V**'s are planed to the correct height above the surfaces *a*. The head is then swung over to the correct angle and a side tool is set to plane down the sides of the **V**'s. Successive cuts are taken down the inclined faces and the gauge shown in Fig. 54 is tried after each cut until slips of tissue paper between the faces of the gauge and the sides of the **V**'s being tested are held with equal pressure. The other pair of **V**'s is then planed with the same tool, after which the head is swung over to the opposite side and the other inclined faces are finished. The corners at the base of each **V** are then squared down, as shown at *a*, Fig. 55, and the work is completed by finishing those surfaces on which undercuts were made.

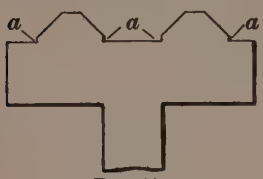

FIG. 55

LUBRICANTS OR COOLANTS IN PLANING

93. Cast iron is planed dry, but a lubricant should be used when cutting wrought iron or steel, to keep the tool from becoming too hot and to produce a smooth surface. Water may be used as a lubricant, but it will rust the machine and the work. Sal soda added to the water will prevent this rusting, but will coat the work with a deposit that must be cleaned off afterwards; however, this coating is more easily removed than rust. When cutting slots in wrought iron or steel, or when making finishing cuts on steel, lard oil is a good lubricant but it is too expensive; if a lubricant of less cost is required, it may be made by mixing equal parts of soda water and lard oil. Kerosene may be used in planing aluminum, or equal parts of kerosene and lard oil may be used. Cutting compounds having a paraffin base, such as are used in machining brass, are not satisfactory for aluminum. Use a roughing tool with 30° to 40° top side rake, cutting on the side of the tool, and a finishing tool with 50° to 60° top side rake rounded so as to cut mostly with the

front or bottom. If small particles of aluminum adhere to the tool, the cutting edge is not smooth enough. Stone the cutting edge carefully, not only to remove metal particles that may adhere in roughing, but to make a perfect cutting edge for finishing. For heavy planer operations, flood lubrication may be used, but rarely, as the table is flat and without means for catching the lubricant. Usually it is sufficient to let the lubricant, often called the coolant, drip on the tool point, as the cutting tool has an opportunity to cool off during the return stroke.

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